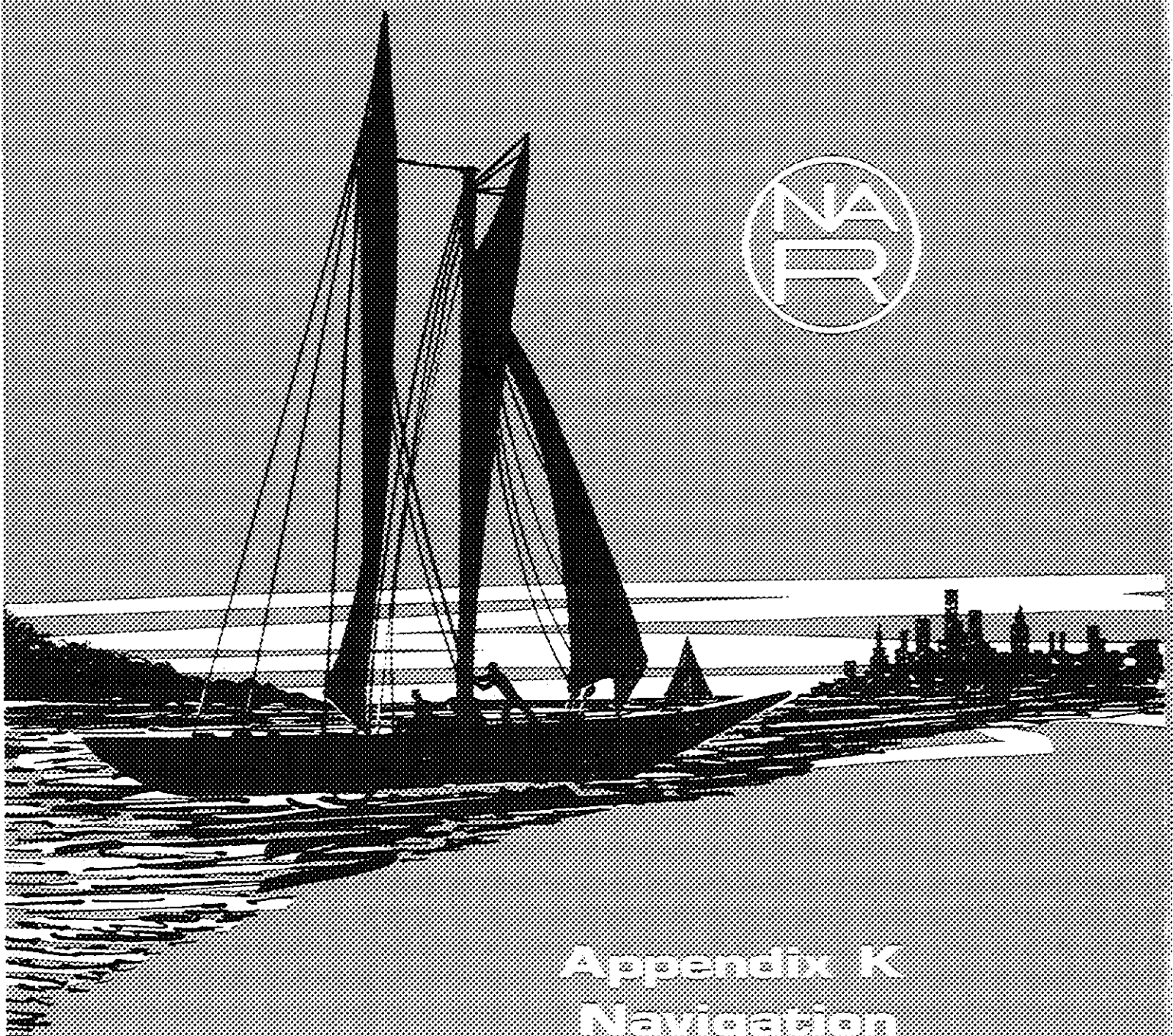
North Atlantic Regional Water Resources Study



Appendix K
Navigation

NORTH ATLANTIC REGIONAL WATER RESOURCES STUDY COORDINATING COMMITTEE
MAY 1972

The North Atlantic Regional Water Resources (NAR) Study examined a wide variety of water and related land resources, needs and devices in formulating a broad, coordinated program to guide future resource development and management in the North Atlantic Region. The Study was authorized by the 1965 Water Resources Planning Act (PL 89-80) and the 1965 Flood Control Act (PL 89-298), and carried out under guidelines set by the Water Resources Council.

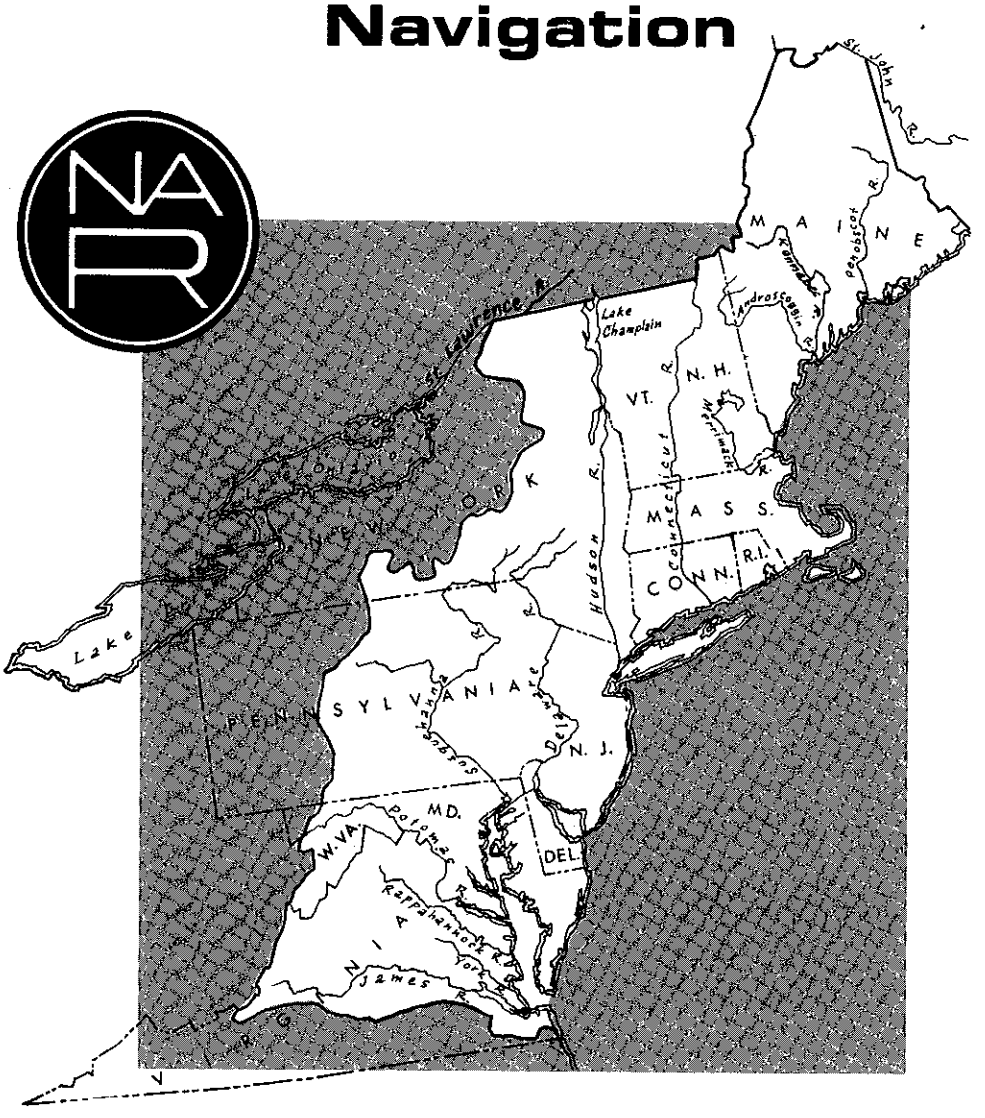
The recommended program and alternatives developed for the North Atlantic Region were prepared under the direction of the NAR Study Coordinating Committee, a partnership of resource planners representing some 25 Federal, regional and State agencies. The NAR Study Report presents this program and the alternatives as a framework for future action based on a planning period running through 2020, with bench mark planning years of 1980 and 2000.

The planning partners focused on three major objectives -- National Income, Regional Development and Environmental Quality -- in developing and documenting the information which decision-makers will need for managing water and related land resources in the interest of the people of the North Atlantic Region.

In addition to the NAR Study Main Report and Annexes, there are the following 22 Appendices:

A. History of Study
B. Economic Base
C. Climate, Meteorology and Hydrology
D. Geology and Ground Water
E. Flood Damage Reduction and Water Management for Major Rivers and Coastal Areas
F. Upstream Flood Prevention and Water Management
G. Land Use and Management
H. Minerals
I. Irrigation
J. Land Drainage
K. Navigation
L. Water Quality and Pollution
M. Outdoor Recreation
N. Visual and Cultural Environment
O. Fish and Wildlife
P. Power
Q. Erosion and Sedimentation
R. Water Supply
S. Legal and Institutional Environment
T. Plan Formulation
U. Coastal and Estuarine Areas
V. Health Aspects

Appendix K
Navigation



Prepared by

North Atlantic Regional Water Resources Study Group
North Atlantic Division
Corps of Engineers, U.S. Army

for the

NORTH ATLANTIC REGIONAL WATER RESOURCES STUDY
COORDINATING COMMITTEE

SYLLABUS

Commercial and recreational navigation have been and will be a significant factor in water and related land resources development and management. They are important not only through their support of water-using industries, but also because of their effects on water quality, erosion, fish and wildlife, landscape quality and other aspects that must be considered in planning.

Future commercial navigation has been estimated by extrapolating historical tonnage trends adjusted to be consistent with present development of land transportation, waterways, port facilities, vessels and the economy, emphasizing the three objectives of the NAR Study: National Income, Regional Development, and Environmental Quality. The results are summarized by Region, by Sub-region, and by Area, the latter analyzing tonnage magnitudes and possible development programs for the more active ports.

Throughout the World, the trend is toward use of increasingly larger vessels, especially for the transportation of petroleum products. These larger vessels are unable to enter NAR ports because of restrictive channel dimensions. In most NAR ports, significant improvements would be very costly due to lack of natural deep-water areas, extensive rock dredging and necessary relocations of bridges, pipelines, cables and/or tunnels. Despite the high costs, benefits may be of a sufficient magnitude to justify some individual port improvements, either channel improvement or off-loading facilities. The development programs of this Appendix indicate possible improvements for which detailed study is considered desirable.

The alternative to individual port improvements is construction of a regional deep-water port or ports. A survey scope study for this area is expected to be initiated in FY 1973. A re-analysis of the development programs will be necessary if a regional port is found to be desirable.

Recreational navigation utilizes an analysis of existing advertised facilities open to the public and is projected in terms of total water craft and total registered craft. Initial capital costs are given for berths and launching facilities. No attempt has been made to distinguish between private and public expenditures, the assumption being that public funds will be used to satisfy those needs not met by private facilities. Data are summarized by Sub-region and Area.

Programs for the development of commercial and recreational navigation in the NAR include information on potential costs.

Navigation should be considered in conjunction with the other needs when considering any program for development and management of water and related land resources.

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CHAPTER 1. INTRODUCTION

Navigation is one of the many uses of water for man's benefit. This Appendix presents information on existing navigation within the North Atlantic Region; citing its trends, its conflicts and the opportunities for its development. This Appendix also draws some conclusions which, when combined with conclusions developed in other Appendices, can be used in the formulation of comprehensive basin programs.

Basic data for this Appendix was provided in a comprehensive report on deep-draft navigation prepared for the NAR Study by the staff of the Board of Engineers for Rivers and Harbors, U. S. Army Corps of Engineers.

PURPOSE AND SCOPE

PURPOSE

Appendix K includes estimates of the range of future waterborne commerce, in terms of total tonnage, in short (2,000 lb.) tons, for the bench mark years 1980, 2000 and 2020, and presents potential development programs and order-of-magnitude costs. The range projected for waterborne commerce is broader in the more distant future as the degree of possible error increases. The limits are such that the range includes projections for Environmental Quality, Regional Development and National Income objectives. Recreational boating is covered through a dissertation on the estimated total craft and total registered craft for the same bench mark years; with an evaluation of the extent of development required to accommodate these craft.

SCOPE

An examination of the condition, adequacy and limitations of the waterways and major port facilities; an assessment of present and future navigation technology, and an analysis of the major trends of waterborne commodities must all be completed before undertaking a discussion of the future activity on and development of the water and related land resources of the North Atlantic Region.

Since this is a framework study, only the major ports and navigation activities have been considered. The quantitative data developed on these ports and facilities is generally comprehensive, although it is not precise in detail. Only those figures found in boating almanacs and similar publications were considered for recreational boating.

STUDY RELATIONSHIP

Appendix K and its data and conclusions must be used in connection with other appendices when considering water resources because navigation activities relate directly and indirectly to many other water and related land resources activities. Sufficient quantities of water must be maintained in the waterways to support navigation, and navigation activities directly affect water quality and the aesthetic and visual qualities associated with water. Economic activities supported or spawned by navigation have a strong influence on water supply, as well as on industrial pollution loading. Finally, navigation, more than any other water resources-connected activity, is controlled by factors lying outside the Region geographically, and outside the institutional purview of the NAR Study. Navigation, therefore, must be viewed against the National and World markets in commodities and transport services. For example, improvements to nearby Canadian ports will most likely affect the commerce handled at ports in the northern portion of the Region. Also, construction of a deep-water facility in Canada, the Bahamas, or another North Atlantic country may have very significant effects on the Region's development programs.

CHAPTER 2. METHODOLOGY

COMMERCIAL NAVIGATION

This chapter explains the procedures followed in estimating future navigation activity, deriving development programs, and estimating potential transportation savings for individual Areas. Regional data for waterborne commerce are given in Chapter 4, "Regional Summary." A step-by-step example of the application of the methodology for Area 2 concludes this chapter.

PROJECTED COMMERCE

A range of prospective waterborne commerce for each area under investigation has been determined to the year 2020. The limits of the range are broad enough so as to envelope estimated tonnages for each of the three major objectives of National Income (NI), Regional Development (RD), and Environmental Quality (EQ). The upper limit is generally defined by maximum Regional Development, and the lower limit by maximum Environmental Quality. The following paragraphs present the methodology used for projecting commerce.

The first step was to determine the National Income projections to 2020. This objective was selected as it is the traditional Corps projection and data were readily available. Once this projection was obtained, the NI average annual growth rate (AGR) was determined and adjustments were made, dependent upon area conditions, to estimate the RD and EQ AGR's. In general, the RD AGR was 0.2% to 0.5% higher than the NI AGR. The EQ AGR was equal to or lower than the NI AGR, dependent upon what lower level of activity would minimize the amount of permanent physical damage required to accommodate prospective commerce. Thus, the range of prospective commerce varies between the maximum RD AGR and the minimum EQ AGR.

National Income projections were determined through two methods. Where available, data from recently completed or currently underway studies for an area were used, and, where applicable, updated for changing conditions. If an area study was not available, the 50-year study period was broken down into three increments -- 1970-1980, 1980-2000, and 2000-2020. The 1970-1980 AGR was determined using historical records of annual tonnage. The 2000-2020 AGR was assumed to be 2.3% as derived from national historical analysis, unless the area's development was expected to be significantly above or below the National average. The 1980-2000 period was chosen as a transition between the first and last planning periods. The 1970-1980 AGR determination requires further explanation. AGR's for the 19-year period 1949-1967 and the 10-year period 1958-1967 were calculated and analyzed to determine a current growth rate. This in turn was adjusted for the conditions listed below to determine the AGR to be used in the 1970-1980 period.

Conditions for which the current AGR was adjusted downward to determine 1970-1980 AGR:

- prospective land transportation development was evaluated as being competitive or non-complementary to navigation;
- waterways are affected by physical constraints on development;
- facilities are inadequate and do not have room for expansion;
- immediate tributary population numbers less than a quarter million and the port serves no major cities (unless accelerated growth is predicted);
- tributary production does not include commodities moved through the port; or
- consumed commodities arriving through the port can be easily substituted for locally.

Conditions for which the current AGR was adjusted upward to determine 1970-1980 AGR:

- prospective land transportation development was evaluated as complementary to navigation;
- the port has an abundance of modern specialized cargo handling facilities;
- the major consumed commodity arriving through the port is best transported by ships; or,
- there is expected to be no port competition within 50 miles.

DEVELOPMENT PROGRAMS

Development programs followed from the level of projected activity, present and anticipated vessels and facilities.

Programs under the Regional Development objective are designed to complement Regional Development in the tributary area. As RD will generate maximum commerce, navigation improvements would be greatest under this objective. The programs presented in Chapter 5, "Sub-regional and Area Summaries," are the maximum improvements considered feasible in each Area for the years 1980, 2000 and 2020. They therefore are considered to be the Regional Development program.

National Income programs would emphasize the most efficient movement of commerce in the area. As identification of NI programs

would require detailed investigations of costs and benefits for prospective commerce, which is beyond the scope of the NAR Study, NI programs have not specifically been identified in the Area Summaries. However, as the commerce handled under this objective is expected to be equal to or less than commerce under RD, the improvements for NI are also expected to be equal or less than those for RD.

Suggested EQ development programs emphasize minimization of permanent effects on the environment while allowing the meeting of projected needs. It should be emphasized that the state of the art of environmental impact evaluation is in a preliminary stage. Research and surveys are urgently required to improve our knowledge. Also required is a systematic comprehensive approach to the assessment of ecological impacts of navigation improvements and operations, and alternatives thereto. Current knowledge indicates that cargo diversion, use of alternative modes of transportation and lightering are devices particularly suited to EQ and should be given detailed consideration in areas having an EQ objective; while channel improvements may be better suited to the other objectives. The off-loading facility alternative has substantial RD and NI benefits but is difficult to assess with regard to EQ. Additional research and study for this alternative is most urgently required.

It should be noted that most environmental groups consider deep-draft commerce operations, especially petroleum, to be, on balance, detrimental to Environmental Quality due to spillages, leakages, discharges, the possibility of large-scale accidents, and the negative effects on recreational use. However, the opposing view has also been championed by some leading authorities in the water resources field. Professor Arthur Maass of Harvard University has stated that "Harbors and ports are built for ships. Ships only are compatible with their scale. Replacing ships with speedboats or with bathers only is to misuse them and in terms of Environmental Quality, to create a noisy, unaesthetic, and absurd-without-being-interesting environment." He states that EQ benefits are due to visual satisfaction of viewing large ships while in port. Professor Maass' comments indicate that EQ is not solely concerned with preservation, but future planning should include consideration of environmental enhancement.

Program costs include only initial capital investments, and were calculated from minimum dredging and facility requirements at 1970 prices or adapted from similar projects discussed in various technical publications. The costs are order-of-magnitude only. Although no attempt has been made to develop annual cost and annual benefits, Chapter 3, "Technology Assessment," does present generalized data for estimating transportation savings from waterway improvements for deep-draft vessels. No attempt has been made to estimate the cost associated with loss in efficiency due to adoption of an objective other than NI.

ALTERNATIVE TO CHANNEL IMPROVEMENTS

This Appendix considers the need for navigation development in the North Atlantic Region under present conditions. Specific development programs thought worthy of detailed study are identified for many Areas within the Region based primarily on past trends and distribution patterns. Emphasis is upon improvement of present channel dimensions and alternatives thereto such as off-loading facilities for more efficient handling of prospective waterborne commerce to the individual Areas.

However, it must be realized that physical constraints, and economic and environmental considerations will impede development of our existing harbors to the extent that they will be unable to accommodate the larger vessels to be used for bulk commerce. Advances in marine transport technology have already resulted in superships requiring depths of 90 feet to enter into world commerce. Vessels presently under design will require depths greater than 90 feet, and depth requirements to 120 feet are forecast within a few decades. There are no ports in the Region with authorized project depths in excess of 50 feet and previous studies indicate that generally channel deepening beyond this depth will not result in optimal efficiency.

The alternative to individual port improvements that may result in the most efficient handling of bulk commodities is construction of a Regional deep-water port, or ports. Shipping interests in recent years have proposed the development of such a facility to handle superships, but they have been unable to develop plans acceptable to all interests involved. As a result, they have begun to consider other countries as the site, primarily Canada and the Bahamas.

The Congress has shown great concern over the possibility of superships being unable to visit United States ports. They have authorized a long-range plan to enlarge the United States merchant fleet, and the Committees on Public Works have authorized studies of survey scope to investigate the feasibility of deep-water ports. The study for this Region covers the Atlantic Coastal area from Eastport, Me., to Hampton Roads, Va., and is budgeted for initial funding in FY 1973.

The construction of a deep-water facility on the Atlantic Coast would have a significant effect on all commercial harbors in the Region. However, analysis of this effect is beyond the scope of the NAR Study due in large measure to the uncertainty of the best location of such a facility. At such time as a deep-water port is to be constructed and the location determined a reanalysis should be made of the findings of this Appendix. Port improvements to efficiently handle commerce from and to the deep-water port may differ significantly from the development programs in this Appendix.

RECREATIONAL BOATING

Leisure time is projected to increase, as are disposable income and population, and it therefore follows that recreational activity will also increase. Leisure time, in terms of recreation days, and income were used as the base for projecting total craft of all types (power and non-power) and dimensions. Population projections were used as the base for projecting State-registered craft, which are generally the larger, powered craft requiring more extensive facilities.

The number of craft were not estimated by objective because projected differences in population and income did not significantly change the projections of craft.

PROJECTED CRAFT

Future boating activity is presented in terms of numbers of registered craft and of total craft. The estimate of registered craft was derived by applying the present per capita registration by State to the median population projection of Appendix B, Economic Base, for the bench mark years 1980, 2000 and 2020 for each Area. The estimate of present total craft assumed there was a boat for each outboard motor estimated to be in use. Participation days per capita were estimated by:

$$\text{Log}_e\ (Y=1) = 0.52\ \text{Log}_e\ X - 3.63 \quad (1)$$

where Y = participation days per capita, and
X = three times per capita income obtained from Appendix B.

The estimates of the total future craft were derived by applying the present craft per participation day per capita to the median population projections of Appendix B.

DEVELOPMENT PROGRAMS

It is beyond the scope of the NAR Study to suggest particular public programs with respect to launching ramps or berthing facilities: First, because they are site specific; and Second, because private capital can be expected to satisfy a part of the demand for facilities, particularly in the more heavily used recreation areas. A qualitative appraisal of the degree of public participation required is presented.

Maryland was assumed to be representative of recreational boating in the Chesapeake Bay area, as was New York in all other areas. It was assumed that registered craft under 16 feet in length and all

non-registered craft would be trailered, and that larger craft would be permanently berthed on water, either at private or public facilities. Accordingly, 67% of the registered craft in the vicinity of Chesapeake Bay would be berthed, while 26% of registered craft elsewhere in the NAR would be berthed. The representative capital cost of a permanent berth was considered to be $1,000. (2)

Trailered craft are assumed to use launching ramps, and their estimated need was the difference between present and future ramps, considering that the number of craft per launching ramp remains constant. The representative cost of a launching ramp with attendant parking areas and comfort facilities is considered to be $20,000. (2)

The resulting costs shown can be considered representative of the initial capital investment for either EQ or RD development. Boating facilities and land-use controls are considered to support an EQ objective by directing where boating will take place. Boating facilities are considered to support an RD objective by stimulating boating participation. It is likely that NE recreational boating expenditures would be less than under the EQ or RD objectives.

No attempt was made to distinguish between private and public costs in any of the Areas. It is assumed that public funds will be used for recreational boating only in the event that private facilities do not satisfy needs. Public support will be required primarily in Areas of low population density. However, the Area Summaries do indicate whether public support is expected to be high, moderate or low.

EXAMPLE OF METHODOLOGY APPLICATION

Area 2 is the first of the 21 NAR Areas in which both recreational and commercial navigation are important. Area 2 is examined in detail to show how the data presented were integrated in the light of the three NAR Study objectives to derive the estimate of future activity, to determine and screen a potential development program, and to estimate costs.

COMMERCIAL NAVIGATION

Projected Commerce

Waterborne tonnage increased at an annual rate of 5.8% for the 19 years prior to 1968, but showed only a 3.3% AGR in the most recent 10 years of that period. The trend of commerce to increase at a decreasing rate led to the selection of 1.9% as the current NE AGR.

The NE AGR, 1970-1980, was estimated at 2.3%, 0.4% greater because of the prospect of increased petroleum tonnage, the availability of good petroleum handling and storage facilities, and a location well suited to take advantage of the good transportation network with no significant competing ports to the north. This increased rate includes allowance for the negative influences of the successful competition by other common shipping, the influences of low population, and the offsetting positive and negative aspects of the waterway dimensions.

The NE AGR, 2000-2020, was estimated at 2.3% as suggested by the National NE trend which was not unreasonable in light of the above estimate for 1980. The NE AGR, 1980-2000, which is the most logical transition between the two, would then be 2.3% also.

The RD AGR is the most optimistic growth that can be expected in the Area. It is considered that growth one percent above the NE AGR, equal to the 1959-1968 rate of 3.3 percent, will not be exceeded during the program period.

Adoption of the EQ objective would minimize commerce to the Area. The minimum rate was selected 0.4 below the NE AGR, equal to the current rate of 1.9%. Further reduction of prospective commerce by means of diversion to other ports, although it may be desirable under a purely EQ objective, is not considered a realistic alternative at this time.

Development Programs

Analysis of historical and prospective commodity distribution indicates that petroleum will be the dominant cargo and therefore harbor development will be geared to the accommodation of tankers. Generally, the waterway to Bucksport has a natural depth of 30 feet for a channel width of 600 feet, and 40 feet for a channel width of 500. Vessels of 35-foot draft currently use the waterway with the aid of some local dredging in the vicinity of the terminal facilities. For these vessels the waterway is hazardous due to strong tidal currents and the presence of two rock pinnacles on the east side of the natural channel. The waterway above Bucksport was also described as hazardous, with authorized project depths of from 13 to 22 feet.

The 1980 program provides for a project depth of 35 feet with adequate widening in the waterway below Bucksport. The initial capital cost estimate of $300,000 was calculated by multiplying the volume of rock to be removed by the cost of dredging.

The 2000 development program providing a 40-foot depth to Bucksport, to take advantage of the greater transportation savings from larger vessels, would require minor dredging at an estimated cost of $500,000.

Similarly, the 2020 program with a 45-foot depth to Bucksport would cost an estimated $1,000,000. Deepening of the harbor to an even greater depth could be accomplished at a relatively minor cost, although prospective commerce indicates that deepening below 45 feet will not be required. The 2020 program also provides for deepening to 35 feet above Bucksport, at an estimated cost of $35 million. The existing project is considered adequate to handle the limited demand in the earlier program periods. Petroleum was also determined to be the dominant commodity in the upstream reaches.

As an alternative to channel deepening for the 2020 program, consideration should be given to an off-loading facility at the mouth of the river, where natural 60-foot depths are available. Commerce after the turn of the century should be favorable for such a facility, which will cost an estimated $10 million. (3) Such a facility, with possible pipeline distribution of petroleum products, may be desirable under the EQ objective. An additional alternative for achievement of the EQ objective, would be the increased use of pipelines for the import of petroleum products. The present pipeline between Portland and Bangor could be expanded for this purpose.

RECREATIONAL BOATING

Recreation Activity

Coast Guard publications provided data on the registered boats by state, 1967-1968 (5). The City and County Data Book 1967 provided state population figures (6). Outboard motor dealers provided an estimate of total engines in use by state, 1967 (7). Appendix B provided the population and per capita income estimates for the bench mark years, completing the information needed to develop the projections of pleasure craft. No change in the ratios of boats to people,or facilities to boats was considered through 2020, but it is believed that these ratios will increase with time.

Recreation Costs

It was assumed that present craft have adequate facilities. There was no local data regarding the relationship of craft to launching facilities in Area 2, so the one launching facility for each 600 craft in Area 6 was assumed to be representative.

The resultant estimated costs of the facilities can only be considered order of magnitude at best for several reasons. There is no certainty that boats owned in Area 2 will be used in Area 2, and there is no practical method for estimating the number of out-of-Area craft that might have to be accommodated in Area 2.

Costs shown for launching facilities are expected to be predominately public expenditures because of the low population density around most boating water.

Berths are expected to be constructed by private enterprise. Their most likely location will be in the southern third of Area 2, where the population is concentrated.

Projections for the other 20 Areas were derived in the same fashion.

CHAPTER 3. TECHNOLOGY ASSESSMENT

The technology of commercial navigation focuses on the transportation and transshipment of commodities. Commercial navigation resulted in the past because of the need to move people and supplies over non-bridgeable water bodies, and continues today because no nation is self-sufficient in the material and goods needed to support the modern way of life.

Only the airplane can compete with ships for trade between continents, and consequently, the force behind technological advancement lies in the competition between shippers. On the domestic front, navigation must compete with the trucking, railroad, aircraft and pipeline industries to maintain present active ports, while at the same time depending on those same common carriers for final distribution of its waterborne commodities.

MARINE CRAFT

The vessels utilized in commercial navigation may be classified in three categories -- barges, shallow-draft vessels and deep-draft vessels. The sizes of deep-draft vessels show rapid historical growth and are the vessels for which most major waterway improvements have been made and will be necessary in the North Atlantic Region. This section will concentrate on those vessels, particularly tankers and dry bulk carriers.

TRENDS IN VESSEL SIZE

With the growth of bulk vessels, many traditional ports are rapidly becoming obsolete in terms of their capabilities to accommodate the vessels and are causing shipping interests to adopt radical changes in cargo handling, storage and distribution techniques at more remotely located deepwater sites. The vessel size revolution is in turn generating continuing pressure for United States port and harbor developments of unprecedented dimensions. Since depths have a major influence on vessel size, shipowners and operators are particularly concerned with the growing inadequacy of existing Federally-constructed-and-maintained channels at major ports to achieve the economies provided by the utilization of larger vessels operating at their designed loaded drafts. Since the beginning of 1960, the number of vessels in the world merchant fleet increased by about 22% while deadweight tonnage expanded some 96%. The increasing size of tankers and bulk carriers accounts for most of the growth in tonnage. Although general cargo freighters comprised nearly 60% of all vessels in the fleet on January 1, 1960, the average size of these ships has increased only moderately since 1960. On the other hand, the average size of tankers and bulk carriers experienced increases of 78% and 196%, respectively, during the same period.

Tankers

Table K-1 indicates the comparative trends in average size, speed and T-2 tanker equivalents for World and United States tanker fleets from September 1945 through June 1969. At the beginning of this period, the T-2 tanker, with a 16,700-ton capacity and a design draft of 30.2 feet, requiring depths of 35 feet, was the prevalent vessel. Today, the maximum vessel size has progressed through the 400,000 d.w.t. plateau and the average size for world fleet tankers has practically trebled to 35,000 tons. To accommodate the average size vessel with drafts of 35 or 36 feet under all conditions, a channel depth of 40 feet is required.

Contrasted with the aforementioned trends in size for tankers built and operated worldwide, changes in the size characteristics of U. S. registered vessels have been much less dramatic. Under existing law, vessels employed in the coastwise and contiguous trades of the States and Territories must be constructed and registered in the United States, and manned by United States crews. The high construction costs and crew wages resulted in the war-built T-2 tanker remaining predominant in the U. S. fleet through the mid-1950s, when a number of major vessel replacements and fleet additions were undertaken by the American petroleum shipping industry. Generally, these new vessels ranged between 25,000 and 35,000 d.w.t. in size with corresponding loaded drafts of 35 feet or less. By the end of 1959, only nine tankers greater than 35,000 d.w.t. had been built for American-flag operation. Since 1960, the relatively small number of tanker additions to the U. S. fleet have centered on vessels of 45,000 to 50,000 d.w.t. capacities with loaded drafts corresponding to 38 to 40 feet, which are about the maximum size which can be accommodated with full loads at most U. S. coastal ports.

Dry-Bulk Vessels

While paralleling the general upward trend in vessel size exhibited by their tanker counterparts, ships designed and built for dry-bulk cargo trade have tended to be somewhat smaller in size. This development is most likely due to a variety of factors including variations in cargo densities between commodities which tend to limit vessel utilization; the fact that ports and related industrial complexes served by these carriers are more numerous and more widely dispersed than for petroleum shipping; and the need to provide more specialized shore-based loading and discharging facilities which are designed for handling particular commodities and/or with the overall dimensions of the vessels themselves.

Before 1950, the typical ocean-going bulk ore carrier was less than 25,000 d.w.t. in size, most being of 10,000 to 11,000 d.w.t. capacity. Ports having channel depths of 32 to 35 feet were generally adequate to accommodate the vast majority of bulk-cargo vessels. In the mid-1950s, construction centered on 30,000 to 50,000 d.w.t. sizes for worldwide vessel movements. A quantum jump in vessel size took

TABLE K-1
TRENDS IN AVERAGE SIZE, SPEED, AND T-2 EQUIVALENTS
OF WORLD AND U. S. TANKER FLEETS,
1945; 1949-68; and June 30, 1969

End of Year	Average DWT		Average Speed (Knots)		Average T-2 Equivalent 1/	
	World	United States	World	United States	World	United States
9-1-45	12,400	14,800	12.9	13.7	0.66	0.83
1949	12,800	14,900	13.1	14.1	0.69	0.86
1950	13,200	14,900	13.2	14.2	0.72	0.87
1951	13,500	15,000	13.3	14.4	0.74	0.88
1952	13,800	15,300	13.4	14.6	0.76	0.92
1953	14,300	16,200	13.6	14.8	0.80	0.96
1954	15,000	16,800	13.9	14.9	0.86	1.02
1955	15,500	17,200	14.0	15.0	0.89	1.06
1956	16,200	17,600	14.2	15.1	0.94	1.08
1957	17,100	18,000	14.4	15.2	1.01	1.12
1958	18,000	18,800	14.6	15.3	1.08	1.18
1959	19,100	19,700	14.8	15.4	1.17	1.25
1960	20,200	20,500	15.1	15.6	1.25	1.31
1961	21,200	21,700	15.2	15.7	1.32	1.40
1962	22,100	22,500	15.3	15.7	1.39	1.46
1963	23,200	23,300	15.4	15.8	1.48	1.52
1964	25,300	24,200	15.6	15.9	1.62	1.58
1965	27,100	24,800	15.7	16.0	1.74	1.63
1966	29,200	25,000	15.7	16.0	1.89	1.65
1967	31,100	25,300	15.7	16.0	2.01	1.66
1968	33,700	25,800	15.8	16.0	2.19	1.70
6/30/69(Est)	35,000	26,000	15.8	16.0	2.27	1.71

1/ T-2 Tanker of 16,765 deadweight tons and service speed of 14.5 knots.

Source: Sun Oil Company Analysis 1949 - 1968
U. S. Maritime Administration

place in 1954 and 1955 with the construction of three 60,000 d.w.t., 39-foot draft vessels. However, these vessels, with their 116-foot beams, cannot transit the Panama Canal. Ore-carrying ships of from 70,000 to 100,000 d.w.t. capacity have appeared in increasing numbers each year since about 1965. Historical trends in dry bulk fleet size distribution in the World fleet for the period from 1953 to 1966 are shown in Table K-2. The greatest relative increase in recent years has been exhibited by vessels of from 60,000 to 80,000 d.w.t., and those over 80,000 d.w.t., respectively. Vessels in excess of 100,000 d.w.t. capacity increased in total from 1 in 1966 to 21 vessels by the end of 1969, and presently comprise about 4% of the total deadweight tonnage in the World bulk fleet. From 1959 to 1969, the average size bulk carrier increased from 19,100 d.w.t. to 30,800 d.w.t.

Existing Vessel Traffic

Like their World fleet counterparts, the trend in tankers and ore carriers plying the North Atlantic Region's waterways is toward larger vessels. Many of these vessels have dimensions and loaded drafts which exceed the theoretical design limits imposed by the existing channel dimensions, taking into account the need for a minimum allowance for 5 feet under the ship's keel to permit safe navigation. For example, in reviewing the trends for vessels utilizing the Delaware River, it is observed that the number of inbound ocean-going tankers with drafts greater than 35 feet have progressively increased from a total of 66 arrivals in 1955, about 1.6% of all incoming tankers, to a total of 992 such vessels, or 34% of the total, in 1968. Even more dynamic are the increases reported in maximum vessel drafts during this period. In 1955, the deepest vessel draft recorded was 36 feet, whereas in 1968, seven tankers having drafts of 50-51 feet (60,000 to 100,000 d.w.t.) were recorded. The larger vessels are generally lightered on arrival in deep water in Lower Delaware Bay to permit passage up-river to refineries in the Philadelphia area. Specific data on iron ore vessels is not readily available. However, vessels of 39-foot draft regularly use the waterway and a vessel having a 43-foot draft was recorded in 1967.

EXISTING FLEETS

Tankers

Table K-3 shows the size distribution of Foreign and United States flag tanker tonnage in service and under construction at the end of 1968. Analysis of these data indicates the following:

- Ports having navigation channels of 40-foot depth can adequately accommodate only about 34% of the existing foreign-flag tonnage and about 77% of the U. S. tanker fleet.

- About 75% of new deadweight tonnage being built for foreign-registry consists of vessels greater than 200,000 d.w.t., whereas only

TABLE K-2
WORLD DRY-BULK FLEET DISTRIBUTION, 30,000 DWT & OVER, 1953-69
(Ocean-going vessels of 1,000 gross tons and over)

DWT GROUP (1,000 tons)	1953-56	1957	1958	1959	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969 1/
TOTAL FLEET	704	763	868	1,016	1,185	1,349	1,592	1,728	1,882	1,971	2,104	2,368	2,609	2,677
30-40	6	12	16	20	26	32	44	68	87	140	191	220	236	241
40-50	3	4	6	9	9	11	17	22	26	34	49	91	120	136
50-60	1	1	1	5	6	7	11	21	26	45	67	105	139	135
60-80	3	3	3	3	3	3	5	7	10	14	34	78	103	110
80-100	-	-	-	-	-	-	-	-	1	3	4	16	37	41
100 & over	-	-	-	-	-	-	-	-	-	-	1	5	10	14
Subtotal, 39,000 DWT and over: (number)	13	20	26	37	44	53	77	118	150	236	346	515	645	677
Subtotal, 30,000 DWT and over: (percent)	1.8	2.6	3.0	3.6	3.7	3.9	4.8	6.8	8.0	12.0	16.4	21.7	24.7	25.3

1/ Figures as of June 30, 1969

Source: Merchant Fleets of the World, U. S. Dept. of Commerce, Maritime Administration
Lloyd's Register of Ships, 1966-67 ed.

TABLE K-3

DEADWEIGHT TONNAGE DISTRIBUTION OF FOREIGN AND UNITED STATES TANKERS IN SERVICE AND UNDER CONSTRUCTION AS OF DECEMBER 31, 1968
(Ocean-going vessels 2,000 gross tons and over)

DWT Group (1,000 tons)	Foreign Fleet		U.S. Fleet 1/		New Vessel Construction Foreign		New Vessel Construction United States	
	DWT	Percent	DWT	Percent	DWT (000)	Percent	DWT(000)	Percent
Under 30	32,391.4	27.1	4,251.8	60.9	2,619	5.0	0	-
30-34	8,043.4	6.7	1,129.2	16.2	221	0.4	136	14.1
35-39	5,726.5	4.8	409.4	5.9	70	0.1	259	26.8
40-44	4,893.5	4.1	82.8	1.1	0	-	0	-
45-49	7,946.5	6.6	524.4	7.5	92	0.2	0	-
50-59	10,988.4	9.2	202.8	2.9	100	0.2	0	-
60-69	9,095.3	7.6	270.3	3.9	180	0.3	183	18.9
70-79	9,656.7	8.1	0	-	384	0.7	228	23.6
80-99	13,979.1	11.7	0	-	2,093	4.0	160	16.6
100-124	8,257.7	6.9	108.4	1.6	1,899	3.6	0	-
125-149	1,398.5	1.2	0	-	1,604	3.0	0	-
150-199	2,942.6	2.5	0	-	4,107	7.8	0	-
200-249	3,531.5	3.0	0	-	26,823	50.8	0	-
250-299	0	-	0	-	10,953	20.8	0	-
300 and over	653.0	0.5	0	-	1,618	3.1	0	-
Total	119,504.1	100.0	6,979.1	100.0	52,763	100.0	966	100.0

1/ Privately-owned vessels excluding U. S. Government.

Source: Sun Oil Company, Analysis, August 1969
Maritime Administration, Department of Commerce, Merchant Fleets of the World, December 1968

3.5% of existing foreign vessel tonnage is accounted for by vessels in this size range.

- With the completion of vessels now under construction, the present predominant size group of 80,000 to 100,000 d.w.t. in the foreign fleet will be replaced by tankers of 200,000 to 250,000 d.w.t. size.

- Contrasted with foreign-registered tankers, tonnage size distribution for the U. S. fleet will undergo little relative change in the immediate future, although a few orders for tankers exceeding 100,000 d.w.t. were placed with United States shipyards during 1969 and the early part of 1970. Pending the outcome of developments and adoption of policies regarding Alaskan oil, tankers built for U. S. registry for use in domestic petroleum trades will generally be limited to about 80,000 d.w.t. size.

Dry-Bulk Vessels

As of January 1, 1970, the World dry-bulk fleet numbered 2,159 vessels having a total deadweight tonnage of 66,431,000, of which about 42% was accounted for by vessels of less than 30,000 d.w.t. size. Table K-4 shows the tonnage size distribution of pure ore carriers; combination ore/oil and bulk/oil types; and other bulk carriers, respectively, It will be noted that for vessels larger than 30,000 d.w.t., no one size group is predominant except that combination bulk/oil type vessels tend to cluster in sizes larger than 60,000 d.w.t. It has been estimated that about 80% of combination-carrier tonnage is employed in petroleum trades and they further assume that the major part of new bulk/oil and ore/oil vessel deliveries will be likewise employed in the immediate future.

Table K-5 shows the deadweight tonnage distribution of new bulk-carrier vessel construction as of January 1, 1970. Of particular significance is the fact that slightly more than one-fourth of this new tonnage is accounted for by combination-vessels larger than 150,000 d.w.t. The average size of vessels on order was 59,100 d.w.t. compared with the average 30,800 d.w.t. for vessels in the existing dry-bulk fleet. None of the new ships are being built for American registry although many are likely to be used in U. S. petroleum and iron ore foreign trades.

FUTURE FLEET COMPOSITIONS

The composition and vessel-size distribution of future ocean-going tanker and bulk carrier fleets will depend on a number of interdependent and presently indeterminate factors. Although past trends, existing vessel characteristics, new ships under construction, announced industry plans for port development and intended vessel utilization provide a basis for estimating the composition of fleets in the immediate

TABLE K-4
SIZE DISTRIBUTION OF EXISTING BULK CARRIERS
AS OF JANUARY 1, 1970
(Deadweight Tonnage in Thousands)

DWT Group	Ore Carriers		Combined Carriers		Other Bulk Carriers		Total		%Total
(1,000 tons)	No.	DWT	No.	DWT	No.	DWT	No.	DWT	DWT
Under 30	178	3,292	40	826	1,199	23,543	1,417	27,661	41.6
30-40	32	1,114	10	347	207	7,225	249	8,686	13.1
40-50	8	370	14	650	134	5,908	156	6,928	10.4
50-60	33	1,796	22	1,228	92	4,982	147	8,006	12.1
60-80	17	1,197	57	4,068	52	3,665	126	8,930	13.5
80-100	2	181	37	3,364	4	331	43	3,876	5.8
100 and over	3	315	15	1,715	3	314	21	2,344	3.5
Total	273	8,265	195	12,198	1,691	45,968	2,159	66,431	100.0%

Source: Fearnley & Egers, World Bulk Carriers, February 1970

TABLE K-5
SIZE DISTRIBUTION OF BULK CARRIERS
ON ORDER AS OF JANUARY 1, 1970
(Deadweight in Thousands of Long Tons)

DWT Group	Ore Carriers		Combined Carriers		Other Bulk Carriers		Total		% Total
(1,000 tons)	No.	DWT	No.	DWT	No.	DWT	No.	DWT	DWT
Under 30	1	24	-	-	200	4,550	201	4,574	16.1
30-40	-	-	-	-	69	2,264	69	2,264	8.0
40-50	-	-	1	46	17	741	18	787	2.8
50-60	1	53	2	110	34	1,849	37	2,012	7.1
60-80	2	152	4	277	21	1,458	27	1,887	6.6
80-100	3	264	28	2,615	2	160	33	3,039	10.7
100-150	2	223	32	3,984	18	2,114	52	6,321	22.2
150 and over	-	-	44	7,543	-	-	44	7,543	26.5
World	9	716	111	14,575	361	13,136	481	28,427	100.0%

Source: Fearnley & Egers, World Bulk Carriers, February 1970

future with a reasonable degree of confidence, forecasts for periods as long as 50 years are admittedly speculative. Fleet compositions 25 and 50 years hence are likely to bear as little resemblance to existing fleets as today's vessels resemble their pre-1950 counterparts. The generally-accepted economic life of ocean-going vessels in the bulk trades is considered to be 25 years or less, in some cases as little as 10 years. Because of the rapidity of change in World shipping and vessel technology, many vessels currently under construction or planned to be built over the next few years will be economically obsolete before 1995. The vessel-size distribution at any given time will be principally determined by a combination of physical and operational constraints; governmental policies of trading nations; economic factors; technological developments in cargo handling and ocean transportation, and, in the final analysis, by the management decisions of corporate firms and individual shipowners and operators. Concern for the marine environment and pollution hazards associated with dredging of deep-draft harbors and channels and the damage potential of casualties to large-size tankers is likely to intensify, rather than diminish. The economic consequences of oil spills and the other costs incurred in providing socially-acceptable solutions to such problems, may be so prohibitive as to ultimately limit the size of vessels in given trades and the locations where their use will be tolerated. These considerations, together with the additional investments required for channel deepening and provision of ancillary cargo handling, storage, and distribution facilities, must be balanced against, and justified by, the expected savings in ocean transportation costs derived from incremental increases in vessel size.

Table K-6 shows projections of the vessel size distribution for world tanker and dry bulk fleets in 1973 and 1983.

Tankers

In developing the above projected frequency distributions, it was assumed that vessels would be retired after 20 years, and maximum vessel sizes would be 300,000 d.w.t. by 1973 and 600,000 d.w.t. by 1983 for tankers and about 200,000 d.w.t. size for dry-bulk carriers. Although tankers of 500,000 d.w.t. have already been designed and vessels of 1 million ton capacity are thought to be technically feasible, maximum tanker size is expected to be under 500,000 d.w.t. for the next several years. Vessels larger than 150,000 d.w.t. will dominate the longer-haul crude petroleum trades while 80,000 to 125,000 d.w.t. class tankers will be employed in trades where cargo volume is insufficient to justify the added investment costs in offshore terminal facilities but which are still capable of entering a number of ports at, or near, design drafts. Vessels less than 80,000 d.w.t. size will be used primarily in handling petroleum products and in relatively short-haul trade. Based on the above

TABLE K-6
PROJECTED VESSEL SIZE DISTRIBUTION -- 1973 AND 1983

DWT SIZE (1,000 tons)	Number of Tankers 1973	1983
Under 20	1,611	1,337
20-40	928	456
40-60	500	317
60-80	292	429
80-100	272	760
100-125	101	397
125-150	16	48
150-200	95	224
200-300	100	371
400-600	-	45
	3,915	4,384

	Number of Dry-Bulk Carriers 1973	1983
Under 10	468	136
10-20	578	368
20-30	495	636
30-40	262	355
40-50	129	254
50-60	122	196
60-80	104	218
80-100	31	76
Over 100	8	22
	2,197	2,261

Source: Oceanborne Shipping: Demand and Technology Forecast, Litton Systems, Inc., June 1968

frequency distributions, the average size tanker in the world fleet will be about 43,200 d.w.t. by 1973, and approximately 80,000 d.w.t. in 1983.

Dry-Bulk Vessels

While the same economic incentives exist as for long-haul petroleum movements, the size distribution of future dry-bulk cargo fleets, including ore carriers, is expected to be concentrated in vessels less than 80,000 d.w.t. size. About one-half of the projected 1983 bulk carrier fleet will consist of vessels under 30,000 d.w.t., with vessels ranging between 30,000 d.w.t. and 60,000 d.w.t. accounting for another 35%. Although the number of dry-bulk carriers in the 60,000 d.w.t. to 80,000 d.w.t. category are projected to more than double between 1973

and 1983, this category will comprise less than 10% of the total fleet. The latter are considered the largest size ships that still maintain flexibility in terms of the draft limitations at most major port areas. Generally, ore carriers tend to be somewhat larger on the average than the all-purpose dry-bulk cargo ship designed to transport a variety of commodities and serve ports having limited capabilities as to draft and size. Recently observed trends reflect construction of multiple-purpose type vessels (ore/oil-bulk/oil) which can carry either liquid or dry cargoes in bulk, which could result in vessel sizes more comparable to those predicted for tankers, but most such vessels are generally likely to be less than 100,000 d.w.t., except for vessels in selective trades. The present physical dimensions of the Panama Canal do not permit the passage of vessels larger than approximately 50,000 to 60,000 d.w.t., 38-foot summer salt water draft, and 107-foot beams. Studies are underway for a new inter-oceanic canal, which if constructed, will determine the size of vessels to be accommodated in the future.

Unless navigable depths in the Orinoco River in Venezuela can be increased and maintained economically, or transshipment facilities provided in deep-water locations, ore ships in the South America-U. S. trade will continue to be limited to vessels of about 60,000 d.w.t. with loaded drafts up to 40 feet. It is anticipated that the average size dry-bulk carrier in the World fleet will show a modest increase from the present 30,800 d.w.t. to 36,000 d.w.t. by 1983.

Fleets for Regional Trade

Removal of physical constraints imposed by present channel limitations will have a major influence on the size of vessels which can be economically employed in future Regional petroleum and dry-bulk trades. The Litton Report and a recent study by the American Association of Port Authorities on the outlook of future vessel sizes for the U. S. offshore trades provides the most definitive analyses of this subject to date. AAPA's forecasts of future ship sizes are similar to Litton's and are essentially predicated on the assumption that change in some form is inevitable and that U. S. interests will undertake the programs necessary to accommodate certain of the largest vessels in order to derive the benefits associated therewith. The AAPA vessel size estimates, while covering a broad range of possibilities, are considered to be particularly applicable to prospective future movements of foreign and domestic crude petroleum, petroleum products, and iron ore traffic in the Region. For example, it is indicated that, by the year 2000, tankers ranging in size from 150,000 to 200,000 d.w.t. or larger having drafts of from 55 to 65 feet will be operating in the crude petroleum trade from the Middle East to the U. S. Atlantic Coast, and from Alaska to this area if the ocean route currently under investigation is found feasible. From the north coast of South America vessels ranging from 80,000 to 150,000 d.w.t. with drafts of 45 to 55 feet, are the more likely sizes due to the relatively short distance and other factors.

It is understood that about 82% of imported petroleum at Atlantic Coast ports now comes from the Carribean area, principally Venezuela, with the remainder divided between the Persian Gulf and the Mediterranean. Channel limitation of the present major supplier of crude petroleum -- Venezuela -- is 60 feet at Puerto La Cruz which can handle vessels up to 200,000 d.w.t. at the present time. Because of the multiplicity of ports served and variety of cargoes carried, U. S. flag tankers engaged in the coastwise North Atlantic-to-Gulf trade are not expected to exceed about 80,000 d.w.t. and 45-foot drafts, and most will average considerably less. Long-distance, large-diameter overland pipelines from traditional refining areas on the Gulf Coast to major markets in the North Atlantic Region now offer effective competition with coastwise tanker movements of clean petroleum products. Future movements of coastwise products will be dependent primarily on the relative economics of tankers vis-a-vis pipelines.

Currently considered plans to provide channel depths of 50 feet at the principal U. S. iron ore receiving ports of Philadelphia, Baltimore and Mobile, if implemented, can be expected to exert a major influence on ore carrier size limits for the United States in the foreseeable future. Consequently, even though a number of the World's major iron ore shipping ports now have an indicated capability for handling ore carriers of 150,000 d.w.t. and larger with drafts greater than 55 feet, it is unlikely that many ships much larger than 100,000 d.w.t. having loaded drafts in excess of 45 to 50 feet can be expected in the North Atlantic Region ore trade in the foreseeable future. In the event that new ore handling, transshipment and distribution facilities are eventually provided in the above noted ports similar to those proposed for handling crude petroleum tankers, it is conceivable that ore carriers of 150,000 to 200,000 d.w.t. would be used in those trades where shipping ports have commensurate facilities to accommodate such vessels. As an example,Tables K-7 through K-10 show the projected vessel size distribution of tanker and ore carrier fleets for various Delaware River trades over the 50-year period from 1975 to 2025. These data indicate the effect that port development may have on future waterborne commerce, or vice-versa.

ECONOMIC EFFECTS OF VESSEL SIZE

The objective of most channel improvement programs is to facilitate the efficient transport of oceangoing cargoes. At present, the primary need for deeper channels is to serve those commodities carried in bulk. Most of those cargoes in the descriptive category of "general cargo" have been adequately served by channels of 35-foot depths or less, and there are few harbors in the United States serving the major general cargo trades that do not have a 35-foot depth. This is not to say that future improvements will not be required for general cargo, however; we are beginning to see a new generation of containerships being built with loaded drafts up to 40 feet that may require channels of 45-foot or greater depth.

TABLE K-7
SIZE DISTRIBUTION OF FUTURE DELAWARE RIVER
TANKER FLEETS FOR PERSIAN GULF AND NORTH AFRICAN
CRUDE PETROLEUM TRADES, 1975-2025
(Figures in percent of total commerce for each trade)

DWT SIZE (1,000 tons)	MEAN DRAFT (feet)	1975	1980	2000	2020	2025
		50-FOOT CHANNEL				
50- 60	40.2	10	10	5	-	-
60- 80	42.4	30	25	15	10	10
80-100	46.1	40	35	30	30	30
100-150	52.4	20	25	35	40	40
150-200	58.3	-	5	15	20	20
Total %		100	100	100	100	100
Average Dwt.	-	87,500	94,500	110,000	119,000	119,000
Avg. draft (feet)	-	47.0	48.0	50.0	51.0	51.0
		ALTERNATIVE DEEP-WATER TERMINAL 1/				
50- 60	40.2	5	5	-	-	-
60- 80	42.4	15	10	5	5	5
80-100	46.1	20	20	15	10	10
100-150	52.4	30	30	25	20	20
150-200	58.3	20	25	35	40	40
Over 200	60.0+	10	10	20	25	25
Total %		100	100	100	100	100
Average Dwt.	-	125,000	130,000	152,500	165,000	165,000
Avg. draft (feet)	-	52.0	52.5	55.0	57.0	57.0
		ALTERNATIVE DEEP-WATER TERMINAL 2/				
80-100	46.1	20	10	5	5	5
100-150	52.4	40	25	15	10	10
150-200	58.3	20	30	25	15	15
200-250	64.0	15	25	30	35	35
Over 250	67.0+	5	10	25	35	35
Total %		100	100	100	100	100
Average Dwt.	-	150,000	175,000	203,000	218,000	218,000
Avg. draft (feet)	-	55.0	58.0	62.0	64.0	64.0

1/ Assumes development of existing depths (62 feet) in Lower Bay.
2/ Assumes access channel at 72-foot depth.

TABLE K-8
SIZE DISTRIBUTION OF FUTURE DELAWARE RIVER
TANKER FLEETS FOR CARIBBEAN PETROLEUM TRADE
1975-2025
(Figures in percent of total trade)

DWT SIZE (1,000 tons)	MEAN DRAFT(feet)	1975	1980	2000	2020	2025
		50-FOOT CHANNEL				
Under 40	38.0(-)	20	10	5	-	-
40-50	39.0	20	10	5	5	5
50-60	40.2	20	15	10	5	5
60-80	42.4	15	20	15	10	10
80-100	46.1	15	20	25	25	20
100-150	52.4	10	15	25	35	40
Over 150	55.0(+)	-	10	15	20	20
Total %		100	100	100	100	100
Average Dwt.	-	62,500	83,000	98,000	111,000	113,000
Avg. draft (feet)	-	41.5	44.8	49.5	50.3	50.5
		ALTERNATIVE DEEP-WATER TERMINAL 1/				
Under 40	38.0(-)	10	-	-	-	-
40-50	39.0	10	5	-	-	-
50-60	40.2	10	10	5	5	5
60-80	42.4	20	25	20	10	10
80-100	46.1	20	25	30	25	20
100-150	52.4	20	25	30	40	40
Over 150	55.0(+)	10	10	15	20	25
Total %		100	100	100	100	100
Average Dwt.	-	86,000	95,500	106,000	115,000	119,000
Avg. draft (feet)	-	45.0	49.0	50.0	50.7	51.0
		ALTERNATIVE DEEP-WATER TERMINAL 2/				
Under 50	39.5(-)	10	5	-	-	-
50-60	40.2	10	10	5	5	5
60-80	42.4	20	15	15	10	10
80-100	46.1	20	20	20	15	15
100-150	52.4	25	30	35	40	40
150-200	58.3	15	20	25	30	30
Total%		100	100	100	100	100
Average Dwt.	-	99,500	109,000	119,000	125,000	125,000
Avg. draft (feet)	-	49.0	50.0	51.0	52.0	52.0

1/ Assumes development at existing depths (62 feet) in Lower Bay.
2/ Assumes access channel at 72-foot depth.

TABLE K-9
SIZE DISTRIBUTION OF FUTURE DELAWARE RIVER
DRY-BULK VESSEL FLEETS FOR CANADIAN AND
LIBERIAN ORE TRADES, 1975-2025
(Figures in percent of total trade)

DWT SIZE (1,000 tons)	MEAN DRAFT (feet)	1975	1980	2000	2020	2025
		45-FOOT CHANNEL				
Under 30	35.0(-)	5	5	-	-	-
30- 40	35.5	10	10	5	5	5
40- 50	38.0	30	25	15	10	5
50- 60	39.9	35	30	25	15	15
60- 80	43.0	15	20	30	40	40
80-100	46.5	5	10	20	25	25
Over 100	49.0(+)	-	-	5	5	10
Total %		100	100	100	100	100
Average Dwt.	-	52,000	55,500	67,000	70,000	73,500
Avg. draft (feet)	-	39.5	40.0	42.5	43.0	43.5
		50-FOOT CHANNEL				
Under 30	35.0(-)	5	5	-	-	-
30- 40	35.5	5	5	5	-	-
40- 50	38.0	20	15	10	5	5
50- 60	39.9	25	20	10	10	5
60- 80	43.0	25	25	30	25	20
80-100	46.5	15	20	30	40	45
Over 100	49.0(+)	5	10	15	20	25
Total %		100	100	100	100	100
Average Dwt.	-	62,000	67,500	77,000	84,000	88,000
Avg. draft (feet)	-	41.5	42.5	44.0	44.5	46.0

TABLE K-10
SIZE DISTRIBUTION OF FUTURE DELAWARE RIVER
DRY-BULK VESSEL FLEETS FOR VENEZUELA AND
OTHER SOUTH AMERICAN ORE TRADES, 1975-2025
(Figures in percent of total trade)

DWT. SIZE (1,000 tons)	MEAN DRAFT(feet)	1975	1980	2000	2020	2025
		45-FOOT CHANNEL				
Under 30	35.0(-)	15	10	5	5	5
30- 40	35.5	20	15	10	5	5
40- 50	38.0	35	30	20	15	15
50- 60	39.9	20	25	35	30	25
60- 80	43.0	10	15	20	30	35
Over 80	44.0(+)	-	5	10	15	15
Total %		100	100	100	100	100
Average Dwt.	-	44,500	50,000	56,000	61,000	61,500
Avg. draft (feet)	-	38.0	39.0	40.5	41.0	41.0
		50-FOOT CHANNEL				
Under 30	35.0(-)	10	5	5	-	-
30- 40	35.5	15	10	5	5	5
40- 50	38.0	30	25	15	10	10
50- 60	39.9	25	30	35	25	15
60- 80	43.0	15	20	25	35	45
80- 100	46.5	5	5	10	15	15
Over 100	49.0(+)	-	5	5	10	10
Total %		100	100	100	100	100
Average Dwt.	-	50,000	57,000	62,000	69,500	71,000
Avg. draft (feet)	-	39.0	40.8	41.0	42.5	43.0

Those commodities forming the greater part of the World bulk trades are, in general order of importance, petroleum, iron ore, coal, grain, bauxite and alumina, phosphate, manganese ore, sugar, salt, sulphur, gypsum, petroleum coke, scrap iron, pig iron and paper pulp. As might be expected, the United States is a leader for many trades, with petroleum, iron ore and coal being the more significant commodities. The North Atlantic Region is a gateway for many of these commodities. Due to the nature and volume of petroleum marketing, tanker needs establish channel requirements at a great number of Regional ports. Iron ore and coal trades are concentrated at fewer ports. For example, most ore receipts are handled through Baltimore and Delaware River ports, while about 90% of coal shipments on the Atlantic move out of Norfolk.

While vessel size requirements for the major bulk commodities vary according to trade, the need for deep channels at many ports is apparent. See section on vessel trends. At present, only four harbor areas in the Region have authorized Federal project depths of 44 feet or more -- Portland, Baltimore, Hampton Roads and New York Harbor. Baltimore has the deepest authorized Federal harbor channel project with a depth of 50 feet. Presently, only Northville, Long Island, can accommodate superships requiring 50-foot depth.

Because of structural differences in hull design, ore carriers and colliers may differ somewhat in design draft from tankers of comparable deadweight tonnage. Also, vessels built for specific trades may vary in length-beam-draft ratios due to some particular restriction on a dimension. An example is the limiting vessel beam dictated by the width of the locks for the Panama Canal. Nevertheless, the relationship of draft to deadweight tonnage for most large vessels will usually fall within certain limits. The enveloping curves of Figure K-1 for tanker draft versus tonnage have been plotted from data for over 300 tankers in the World fleet.

Benefits from channel improvements accrue to vessel operators through more efficient and safer operation and, either directly or indirectly, to shippers or receivers of goods. While a few new harbors are created in this country from time to time, the more common type of benefit analysis concerns the improvement of existing harbors through channel deepening and widening or new channel alignments to reduce transit time. In the deepening process, channels are also often widened and straightened. Deepening existing harbor channels permits some present vessels to enter with deeper drafts and greater cargo loadings, others to enter on all or certain stages of tide, or new and larger vessels to enter with full or partial cargoes depending on the depth to be provided.

Vessel Transportation Costs

Estimates of operating costs for representative bulk carriers and tankers have been derived from information obtained through conferences with numerous ship operators, shipbuilders, and representatives of

FIGURE K-1

TANKER DRAFT VS. DEADWEIGHT TONNAGE

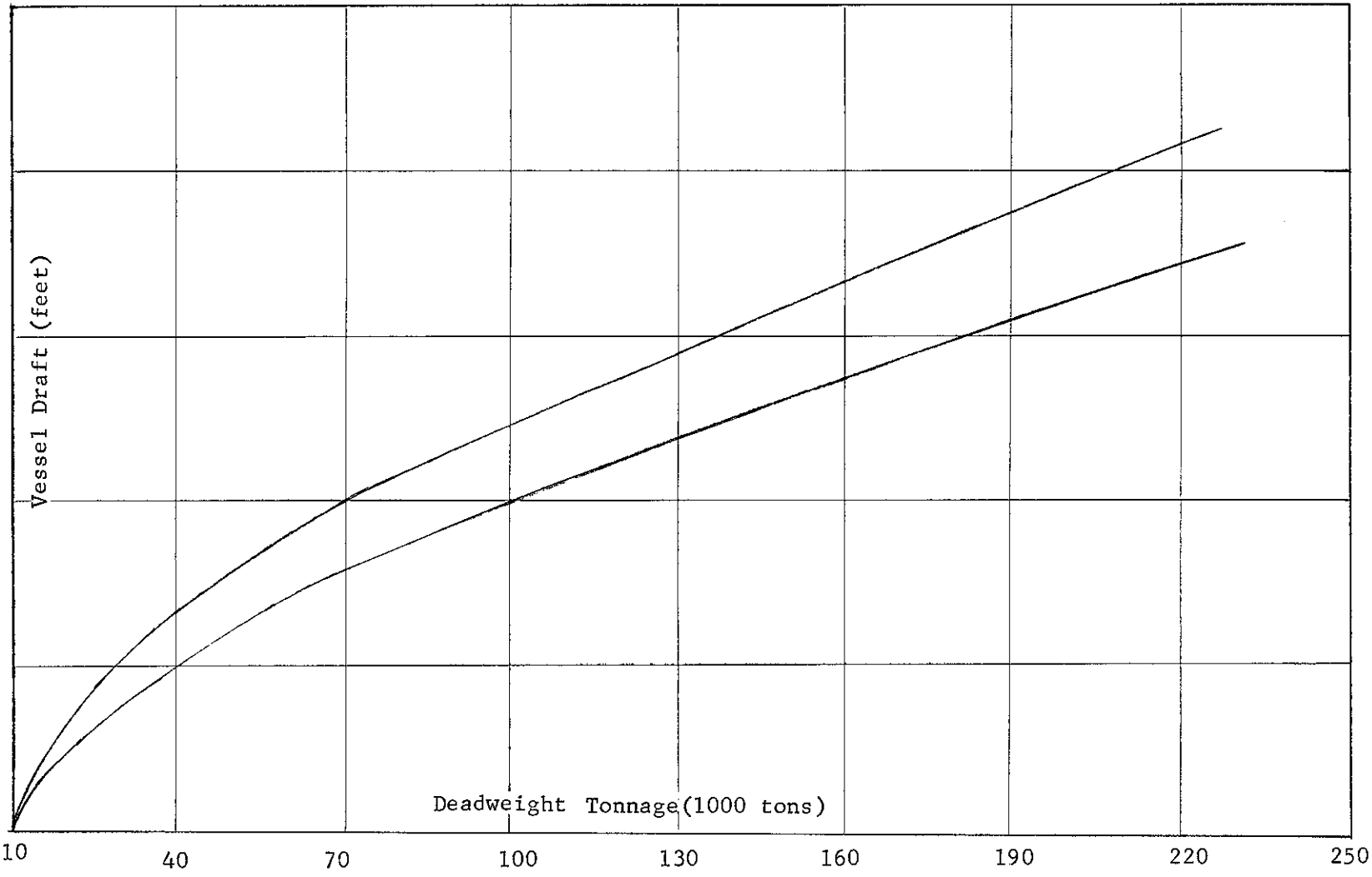


TABLE K-11
FOREIGN TANKER HOURLY OPERATING COSTS
(Costs in January 1971 dollars)

VESSEL SIZE (d.w.t.)	FOREIGN FLAG	
	At Sea	In Port
26,000	183	153
37,000	213	181
47,000	236	197
60,000	261	218
70,000	278	229
80,000	299	247
90,000	313	257
100,000	330	269
120,000	357	294
150,000	399	334
210,000	477	409
250,000	529	457
326,000	633	556

the United States Maritime Administration, and from data contained in maritime publications. Costs are computed separately for both foreign and United States flag vessels; United States registry requires that vessels be built in United States shipyards and manned by American crews at much higher cost than foreign flag vessels. Normal speed for all vessels is assumed to be 16 knots, with horsepower requirements and fuel consumption computed accordingly. Basic cost units are vessel hourly operating costs -- including components of interest and amortization of the vessel investment, crew wages, fuel, maintenance, repairs, stores, supplies, subsistence, insurance, profit and taxes (when applicable). The annual operating season is assumed to be 345 days, with a 20-day outage for repairs. Table K-11 presents the hourly operating costs for various sizes of foreign flag tankers.

To illustrate the possible savings through improvements to accommodate larger vessels, consider the curves of unit transport cost of bulk cargo on Figure K-2. The costs shown have been computed for foreign-flag tankers assuming shipbuilding costs if contracted for in 1970 and current operating costs (January 1971). For a 10,000-mile round trip, cargo carried in a 60,000 d.w.t. tanker would be delivered at $2.65 per net ton. If the ship size were doubled, the delivered cost could be reduced to $1.85 per ton for a savings of $0.80 per ton. The 60,000 d.w.t. ship would require a channel of about 45-foot depth and the 120,000 d.w.t. vessel would require a depth of 55 feet or greater. Further economy would result if it were permissible to transport in a 240,000 d.w.t. vessel ($1.35 per ton).

It should be noted that the unit savings for bulk cargoes are less than those for general cargo carried in containerships in comparable situations due to the higher operating costs for the more sophisticated and speedier containerships, so that the illustration can serve as a conservative estimate of possible savings for all cargoes.

FACILITIES

A harbor is a refuge for marine craft from storms, and becomes a port when piers, wharves, open and covered storage areas, railroad and trucking access, and special loading and unloading equipment are constructed to handle cargo. The natural port sites in the North Atlantic Region have long been developed, so that technology is now focused on improving port efficiency.

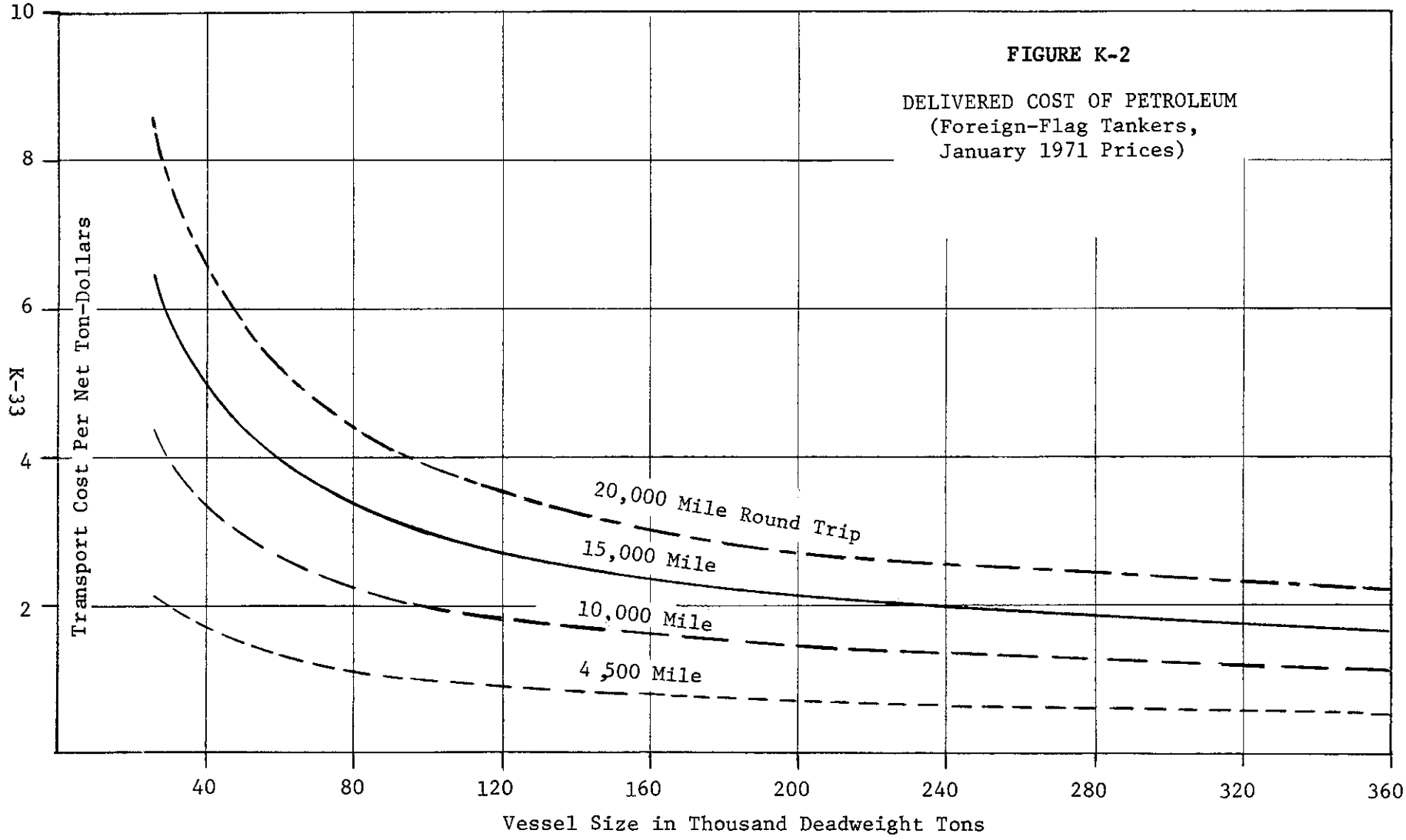
Technology has been applied to reduce the number of times that commodities must be handled, to increase mechanized handling of commodities, and to accommodate larger vessels to take advantage of their economies of scale.

Containerization is an example of reduced handling combined with increased reliability. By loading high value general cargo in standardized containers, special mechanized handling equipment could be designed and built. Loading and unloading time has been slashed from as much as 36 hours to as little as 12 hours. Depending on the integration of harbor and land transportation, 5 to 10 days can be cut from the delivery time from origin to destination. The disadvantages, however, are not slight considering the highly urbanized nature of most NAR ports. Break-bulk handling of general cargo required only about 2.5 acres of covered storage as a minimum per berth, whereas the handling of containers generally requires 15 to 26 acres of open area per berth. However, acreages per berth for containers can be 5 or even less under special circumstances.

Special handling equipment for coal, ore and petroleum has been developed and installed in many ports. Unfortunately, volume must be in the millions of tons before such equipment becomes economically feasible.

FIGURE K-2

DELIVERED COST OF PETROLEUM
(Foreign-Flag Tankers,
January 1971 Prices)



Larger vessels can be accommodated by deepening and widening present channels, or by establishing commodity handling facilities in deep water.

Moorage systems can be established offshore in deep water connected to shore by pipeline and capable of withstanding hurricane force winds and seas. Platforms can be constructed for handling liquid or solid commodities in the same manner. Liquids, such as petroleum or chemicals, are not the only commodities pipelines can handle. Special slurries of ore and coal are also technologically feasible for transport by pipeline. An iron ore pipeline right of way has recently been acquired by a Canadian mining company.

CHAPTER 4. REGIONAL SUMMARY

This summary is an overview of the major factors considered to influence navigation development in the North Atlantic Region, with an evaluation of their present and future regional effects on navigation. Regional generalizations cannot be meaningfully applied to any particular area, but they do provide a standard against which areas in a region and other regions can be compared.

HISTORY OF COMMERCIAL NAVIGATION

The development of harbors and coastal channels in the United States has played an important role in the growth of our Nation since colonial times. During the early years of our history, the waterways were followed to explore the wilderness, and in later years their improvement and maintenance by both governmental and private interests gave rise to extensive industrial progress.

The first permanent European Colonies in North America were established along the Atlantic Coast. Large rivers with long tidal reaches, such as the James, Delaware, Hudson and St. Lawrence, provided relatively easy access by navigation for miles into the interior. Fishing and fur trading were the principal industries of the North Atlantic Region prior to the early 1600s. Exploitation of the forest along major rivers began in 1623, and the development of shipbuilding occurred soon afterwards. Coastal towns throughout the North Atlantic Region quickly became centers of commerce, and trade via the rivers was carried on with the Indians, and French and Dutch settlers. Navigation improvements were generally limited to marking channels, and the establishment of wharves and piers at plantations. By the 1800s, ships were used to export agricultural products, fish, lumber and ice, and to import the staples of molasses, sugar, salt, iron and coal.

It was not until 1802 that the first Federal appropriation was made for repairing and erecting public piers in the Delaware River.

The earliest harbor improvements undertaken by the Federal Government were begun in 1824 on the Great Lakes. Direct responsibility for these improvements was assigned to the U. S. Army Corps of Engineers. Other harbor developments were made from that time through 1850 along the Atlantic and Gulf Coasts by the Corps of Engineers under Federal appropriations. Efforts to stimulate navigation were made through the 1850s to the 1890s by repairing and erecting public piers as well as channel improvements in 25 rivers and harbors.

The improvement of harbors in the North Atlantic Region by the Federal Government has been a progressive development to keep pace with the growth of oceanborne commerce and shipping requirements. Few coastal bays and rivers on the eastern seaboard had natural depths as great as 20 to 30 feet. These natural conditions have been improved over the years from the relatively shallow depths necessary to serve sailing craft, to the greater depths required by steam navigation, and finally to meet the needs of modern ocean liners and tankers.

LAND TRANSPORTATION

Rail lines and highways have followed the historical avenues of colonial expansion and are therefore found generally paralleling the coast and navigable rivers. The best historical ports such as Boston, Philadelphia, and Baltimore represented a terminus to efficient navigation and became centers of transportation from which high-speed, heavy-duty roadways and rail lines radiate to all quadrants of the compass. New York City was less important as an independent center of transportation because of fine nearby waterways (Hudson River, Long Island Sound), and because it was an island with extensive wetlands to the west. Newport News development as a land transportation center was slowed because of swampland to the south.

The major highways and railroads, which cannot be readily accounted for by the reasoning above, are generally seen to be either the shortest feasible line between the major cities or extensions of the radiating networks of Boston, Philadelphia, Richmond, or Baltimore.

As railroad construction was much cheaper than hard-surface road construction, and was more facile to place in rough terrain, railroad tracks blanket the entire Region. Many tracks are not now in regular use due to the competition for passengers and freight from private and common carriers.

The established lines of transportation tend to strongly complement the high volume (tens of millions of tons) ports which are along them, as well as those low volume (tens of thousands of tons) ports not readily accessible to them. The established lines compete strongly, however, with the medium volume ports (hundreds of thousands of tons), because they are generally also located along them.

WATERWAYS

CONDITIONS AND DEVELOPMENT RESTRICTIONS

Generalizations of a Regional nature are difficult to make about waterways because of varying conditions such as tidal range, depth, development problems, and normal weather, all of which impose restrictions on navigation.

The water level rises and falls twice daily in ports and harbors located in the coastal zone of the NAR due to the influence of the sun and moon. The average tidal range varies tremendously but changes gradually from 11 feet in the north to 2 feet in the south. A high tide range can be hazardous in coastal waterways because it can generate strong tidal currents which complicate ship handling. It can also be beneficial since vessels whose draft requirements exceed channel depths at low tide may pass near high tide. A low range is desirable for reasons of stability in ports because vessels may be tied to a pier for a day or more in the process of loading or unloading.

Weather can adversely affect navigation and its effects on an annual basis tend to worsen as one progresses north. Northern inland or fresh water canals and waterways may be frozen sufficiently to prevent navigation from five to six months each year. Those ports located in estuarine waters, though not directly affected by icing, can be dangerous to shipping because of unpredictable ice flows or spring freshets. As one progresses north, fog becomes more common, reducing the days of good visibility and increasing hazards to shipping. Hurricanes are a virtually unpredictable occurrence, with somewhat higher incidence as one progresses south.

Depth-related development restrictions are quite common in the northern areas because of rock, which is at least three times as costly to remove as sediments. Depth restrictions are common in the central areas because of potential ground water contamination. Depth restrictions in the southern areas are largely due to the large volume of material that has to be removed, since southern waterways tend to be shallow.

Development restrictions also exist because of past development around waterways. The older ports have shore facilities which were not constructed with allowances for potential deepening to 40 feet or more. There may be bridges or tunnels which may be extraordinarily expensive to move. Waterways may be extensively developed but too narrow to support two-way traffic of modern ships. Many ports, such as Boston, have inner harbors which have extensive development restrictions but have outer harbors that can be developed further.

AVAILABLE DEPTHS

Most ports have had some parts of their waterways improved. Throughout the North Atlantic Region, there are waterways designed to pass vessels of 35-foot draft. Baltimore (Sub-region E) has an authorized depth of 50 feet although the controlling depth is about 43 feet. Portland (Sub-region B), New York (Sub-region C), and Hampton Roads (Sub-region F) have waterways with depths to 45 feet. The Delaware River (Sub-region D) has a depth of 40 feet beyond Philadelphia to a point 5 miles south of Trenton, N. J.

These waterway depths compare favorably with ports elsewhere in the United States.

COMPETITION

The Gulf Coast, which is the origin of a majority of the domestic petroleum traffic in the Region, has an incidence of 35-foot depths equal to the East Coast. In addition, there are one or two ports with depths of 38 to 42 feet in each of the Gulf Coast States, but none deeper. Since the tide range along the southern coast is on the order of one foot, southern ports are presently inferior to those in the North Atlantic Region in their ability to pass vessels. However, they generally do not have the rock and tunnel problems that many of the Region's ports have, and thus are not a limiting factor when considering the deepening of regional ports.

The West Coast has some waterways much deeper than those in the North Atlantic Region. California and Hawaii have some waterways with 55-foot depths. Puget Sound offers almost unlimited depth, but its port access waterways are generally about 35-to-40 feet deep. Alaskan waterways are rarely deeper than 30 feet, but experience an average tide range of about 26 feet. The remainder of the West Coast experiences tidal ranges similar to the East Coast at the same latitude.

The North Atlantic Region is well located to compete for European, Canadian, Mid-Eastern, and South American trade. Some major foreign ports trading reciprocally and/or competively with ports in the Region have more highly developed waterways. For example, in Canada, Nova Scotia has a petroleum refinery complex capable of accommodating tankers of 300,000 d.w.t. Quebec has ore docks capable of accommodating bulk carriers of 200,000 d.w.t. In Europe, Ireland has petroleum facilities capable of accommodating 326,000 d.w.t. tankers. In the Middle East, Kuwait has petroleum facilities equal to those of Ireland; and Japan has coal and ore docks capable of accommodating ships of 130,000 d.w.t.

SERVICE FACTORS

Service Factors include production, consumption, and density of population within each area.

Production is evaluated for potential exports. Only Areas 9, 10, 18, and 21 strongly support commercial exports. The major foreign, exported commodities are scrap iron and coal. There are additional exports in almost every other port but not in the same magnitude. Domestic exports generally consist of sand and gravel, coal or petroleum. Petroleum primarily originates in Areas 14 and 15 with destinations throughout the Region. Sand and gravel is produced so universally, it is usually only locally-transported.

Consumption is evaluated for necessary imports. The NAR is not self-sufficient in either petroleum or iron ore, and a significant portion of the total U.S. ore refining and steel manufacturing lies in the Region.

Population is evaluated in terms of volume demand. Regional population distribution is extraordinarily favorable to navigation as its density is not uncommonly 10,000 or more per square mile along navigable waterways. In such densities, the demand for even a small durable item may be of sufficient quantity to require shipment in volumes susceptible to waterborne competition.

WATERBORNE COMMERCE

Total foreign and domestic oceanborne commerce in the NAR increased from approximately 470 million tons in 1955 to almost 510 million tons in 1968. The four major bulk commodities of metallic ores, coal, crude petroleum and petroleum products comprised about 79% of all waterborne tonnage in 1966. General cargo accounted for only 13% of the volume by weight, but 68% of the $40 billion value of the total tonnage.

Projections of these major waterborne commodities were based on information and future estimates contained in studies undertaken by various Federal and non-Federal agencies and organizations and modified through discussions with knowledgeable individuals. A range of values is presented which are broader in the more distant future as the degree of possible error becomes greater. It is considered that the range will account for future technological innovation which cannot be foreseen at this time.

Figure K-3 shows the estimated range of total commerce assembled from an analysis of each of the major waterborne commodities.

COMMODITIES

Metallic Ores

Metallic ores shipped in the North Atlantic Region consist almost entirely of iron, aluminum, manganese and chrome, and are imported to the Region. A negligible volume moves in the export and domestic coastwise trades. Total foreign ore traffic was approximately 30 million tons in 1966, of which about 95% was received in Sub-regions D and E. Iron ore amounted to 27.1 million tons. For the purposes of this report, the general trends of the steel industry are considered to be characteristic of each of the metallic ores.

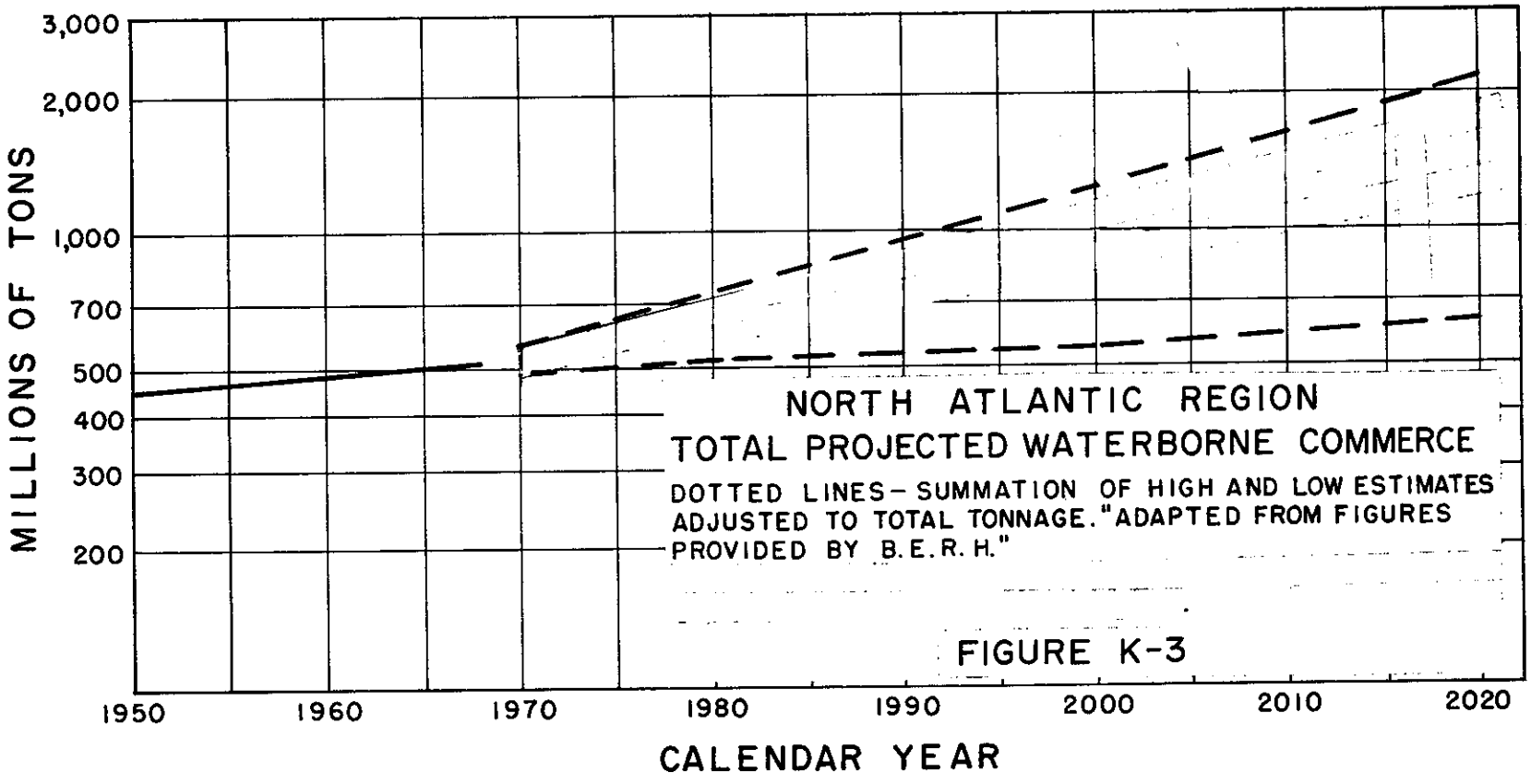

3,000
2,000
1,000
700
500
400
300
200
MILLIONS OF TONS
1950
1960
1970
1980
1990
2000
2010
2020
CALENDAR YEAR
NORTH ATLANTIC REGION
TOTAL PROJECTED WATERBORNE COMMERCE
DOTTED LINES - SUMMATION OF HIGH AND LOW ESTIMATES ADJUSTED TO TOTAL TONNAGE. "ADAPTED FROM FIGURES PROVIDED BY B.E.R.H."

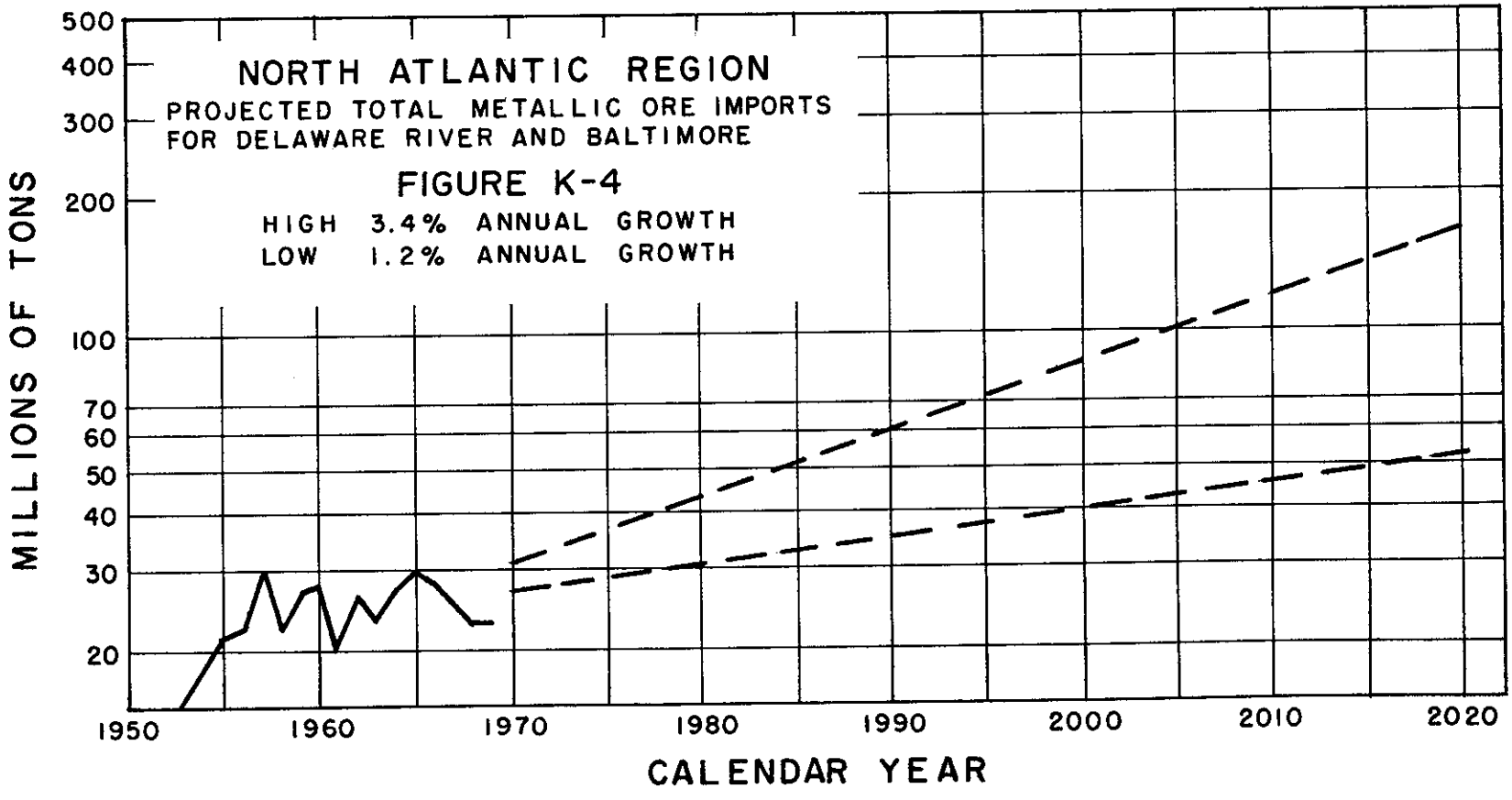
FIGURE K-3

During the period 1950 to 1966, U. S. raw steel production increased at an annual rate of 1.4%, paralleling the population growth as per capita consumption remained approximately constant. World production of steel grew at an 8.3% annual rate. The relative decline of U. S. steel production to that of the World, is attributed to competition from other materials such as, plastics, the development of lighter, stronger steel, foreign competition resulting in declining exports and increasing imports and a downward trend of some steel consuming industries.

Prior to World War II the location of the steel industry in the U.S. had been raw material-oriented. The Great Lakes were used to ship ore inexpensively to steel-producing centers in Pennsylvania and Ohio, which are close to sources of high-grade coking coal. Since the war, the location pattern has become more market-oriented. During the period 1947-1965, the Region's share of the total U.S. production rose from 10% to 18%. Steel consuming industries have shifted in a similar manner. Most of the ore imported into the Region is consumed by steel producing centers in Sub-regions D and E, but some of the ore is transhipped by rail outside of the Region. The exact volume of ore moving inland from the NAR is unknown, but may be as great as 25% of the total. In the early 1950s, the United States was importing approximately 8% to 19% of its iron ore, and now imports about 33%. South America, Africa, and Canada are our major sources of ores. Figure K-4 presents the past and projected ore imports for Sub-regions D and E on the basis of the estimated future growth of the steel industry located in the North Atlantic Region only. A comprehensive report, "Steel Imports," was published in December 1967 for the Senate Committee on Finance. The Board of Engineers for Rivers and Harbors has estimated the Region's high and low annual rates of steel production increases to be 3.4% and 1.2%, respectively. Imports of metallic ores were projected at the same growth rates. These rates do not take into consideration the trend of using less iron ore per ton of steel. It is considered that these growth rates are applicable to all metallic ores imported into or through the region.

Crude Petroleum

Crude oil is primarily marketed to refineries which convert it into a variety of finished products. Historically, the nation's refineries have not located where crude production has occurred, because of their large number of scattered locations, but have concentrated in the coastal areas accessible to tanker transportation, large inland population concentrations and pipelines.


NORTH ATLANTIC REGION
PROJECTED TOTAL METALLIC ORE IMPORTS
FOR DELAWARE RIVER AND BALTIMORE
FIGURE K-4
HIGH 3.4% ANNUAL GROWTH
LOW 1.2% ANNUAL GROWTH
MILLIONS OF TONS
500
400
300
200
100
70
60
50
40
30
20
1950
1960
1970
1980
1990
2000
2010
2020
CALENDAR YEAR

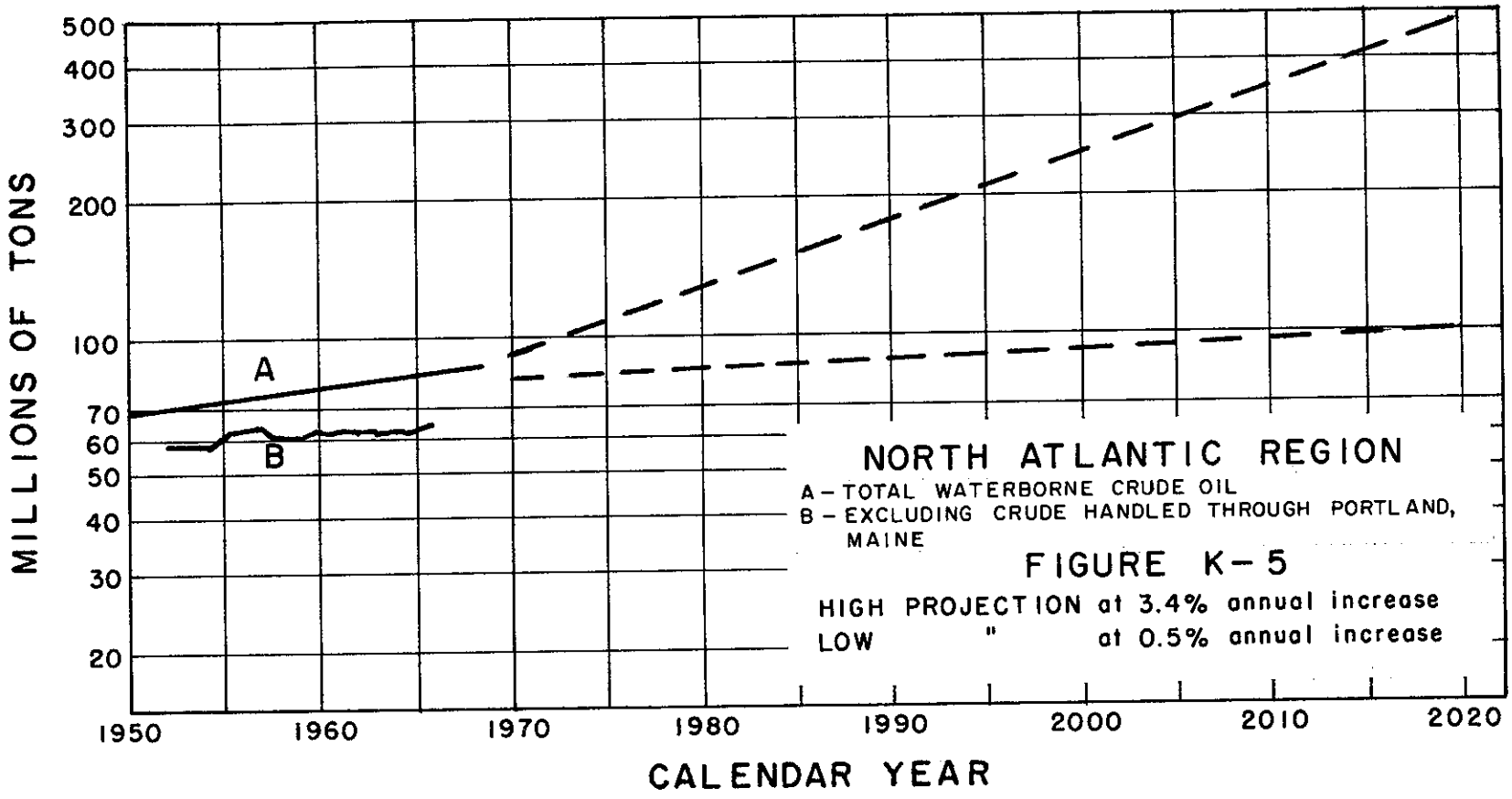
As of January 1968, refining capacity in the North Atlantic Region was 12% of the total U.S. capacity. (14) From 1950 to 1957, refinery production in the NAR increased at a compound annual rate of approximately 3.4%. From 1958 to 1966, it increased at only 0.5%. A voluntary crude oil import program, instituted in 1957 for reasons of national security, was the reason for the decline. The effect of the program was merely to shift imports from crude to refined products, and resulted in little change in the total petroleum import trend. In 1959 the Mandatory Oil Import Control Program was established and continues in effect at the present time. All imports, with the exception of those from Canada and Mexico, are licensed under a quota system. The Canadian and Mexican imports, which are not allocated or limited, are included, however, in fixing the allocations of the other foreign countries, thereby serving to reduce their allocations. Since most of the crude oil from the Middle East and Central America is refined on the East Coast, the refineries in the NAR have probably been most negatively influenced by the import controls. The greater use of domestic crude oil in the U.S. has resulted in a relative shift of the national refinery complex to the Gulf Coast. Therefore, the trend has been to refine domestic crude oil near its source and transport the product via ship or pipeline.

Total receipts of crude oil in the Region amounted to approximately 76 million tons in 1966, 72% of foreign origin. Its distribution was 52% over the Delaware River, 23% through the New York-New Jersey Channels, and 22% through Portland, Me.

The import control programs and pipelines will continue to have the greatest effect on the future range of crude petroleum imports into the North Atlantic Region. If strict import quotas continue, the present trend of 0.5% annual growth is expected to continue and is the low range projection shown in Figure K-5. If import quotas are relaxed, the estimated total crude oil consumption will exhibit a growth rate similar to that during the period before the import quotas were imposed, which explains the 3.4% high projected growth rate.

Residual Fuel Oil

Approximately 60% of the total U. S. sales of residual fuel oil presently occur in States wholly or partially within the Region. Its major uses include electric power generation, industrial processes and the heating of large commercial and industrial buildings. Although Regional sales of residual fuel oil increased at an annual rate of 1.3% during the period, 1950 to 1963, the total national demand has remained relatively constant. Residual oil is more competitive with other fuels in the Region because of the availability of low-cost,


MILLIONS OF TONS
500
400
300
200
100
70
60
50
40
30
20
A
B
1950
1960
1970
1980
1990
2000
2010
2020
CALENDAR YEAR
NORTH ATLANTIC REGION
A – TOTAL WATERBORNE CRUDE OIL
B – EXCLUDING CRUDE HANDLED THROUGH PORTLAND, MAINE
FIGURE K – 5
HIGH PROJECTION at 3.4% annual increase
LOW " at 0.5% annual increase

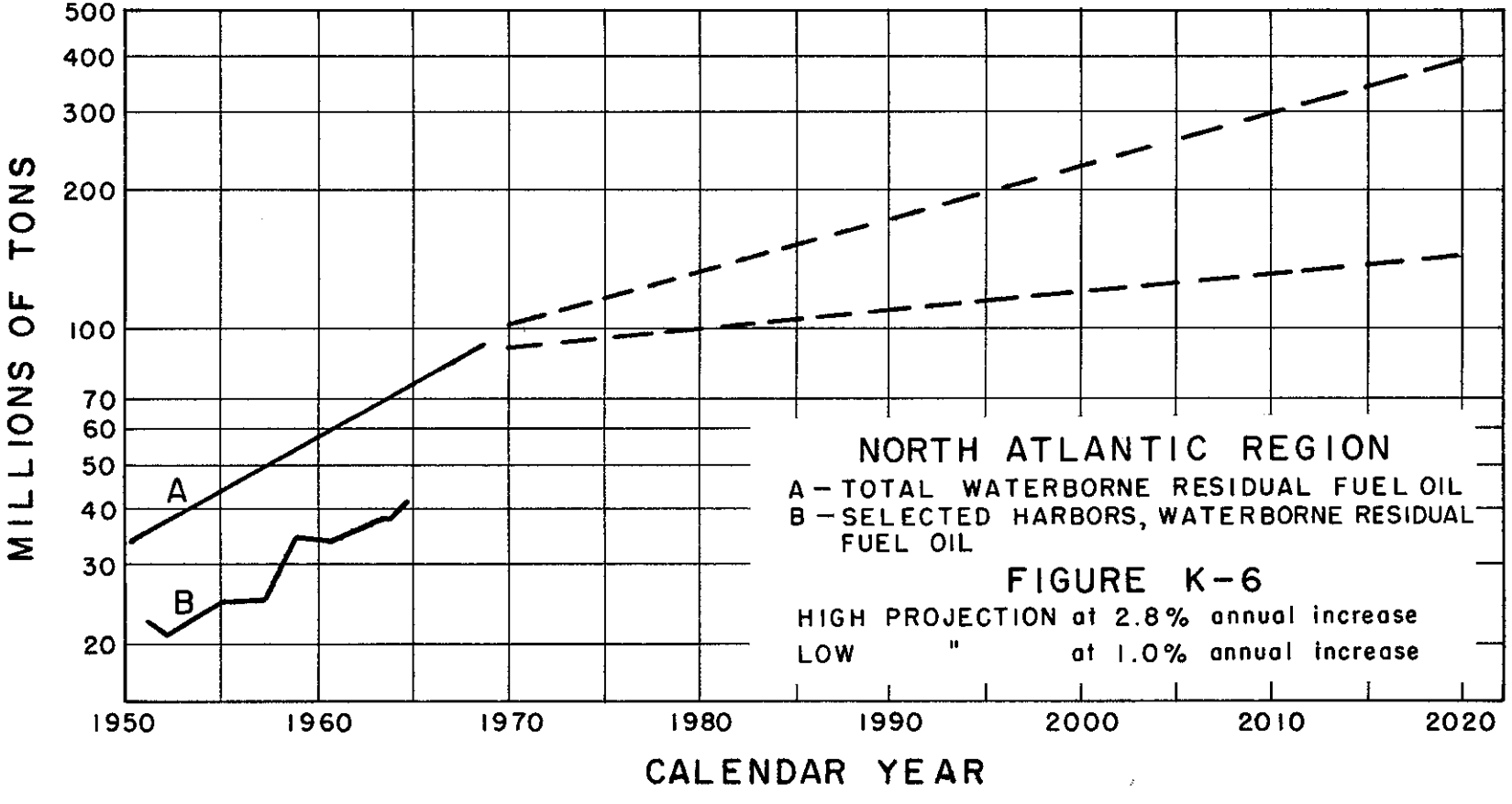
deep-draft navigation, and the importation of cheaper foreign oil. Residual fuel oil is a low-profit by product of the refining process, and its proportion in domestic refining has been reduced from 20% in 1950, to approximately 8% in 1966. The import quota program sets the allowable limit on residual oil as the difference between the total demand and available supply from domestic refineries. Domestic residual fuel oil is expected to continue to decline by the further upgrading of heavy oils into lighter products. In addition, to comply with air pollution regulation of sulfur content, low sulfur-content African residual petroleum is becoming very attractive. Total average annual compound growth rates for Regional waterborne residual fuel oil have been estimated by the Board of Engineers for Rivers and Harbors to range between a high of 2.8% and as assumed low of 1.0%, as shown on Figure K-6.

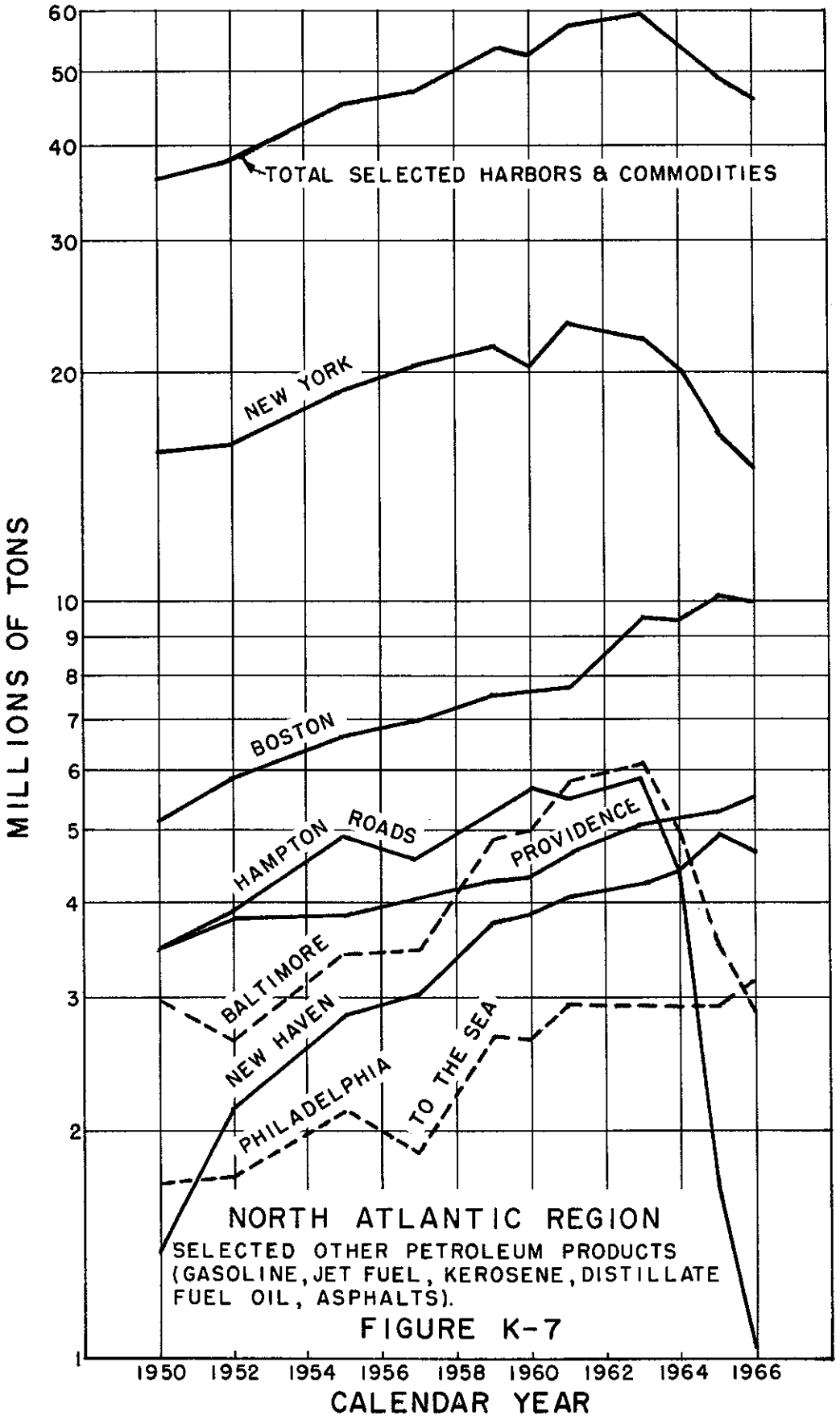
Other Petroleum Products

In the North Atlantic Region, petroleum products, other than residual fuel oil, are primarily domestically supplied by refineries in the Region and through transport of products by pipeline or vessel from Gulf Coast refineries. Sub-regions A and B are serviced almost entirely by waterborne shipments, 75% of which originate along the Gulf Coast. There are six pipelines with a total average annual capacity of 129,000 barrels a day from the New England coast to large inland cities.

The market area for petroleum products originating in refineries of Sub-region D, includes the states of New York, Pennsylvania, New Jersey and Delaware. Ten pipelines with a total capacity of about 125,000 tons per day, interconnect the Philadelphia and New York City metropolitan areas.

The petroleum demand can be, and currently is partially, satisfied by pipeline shipments from Gulf Coast refineries via the Colonial Pipeline System which has a capacity approaching 1 million barrels per day. The past trend of waterborne receipts of petroleum products other than residual fuel oil at selected harbors of the North Atlantic Region is shown in Figure K-7. It should be noted that representative New England harbors have had a continuous increase in waterborne receipts since 1950. However, the impact of the Colonial Pipeline on the receipts of New York and other Mid-Atlantic ports is clearly shown.


MILLIONS OF TONS
500
400
300
200
100
70
60
50
40
30
20
A
B
1950
1960
1970
1980
1990
2000
2010
2020
CALENDAR YEAR
NORTH ATLANTIC REGION
A – TOTAL WATERBORNE RESIDUAL FUEL OIL
B – SELECTED HARBORS, WATERBORNE RESIDUAL FUEL OIL
FIGURE K-6
HIGH PROJECTION at 2.8% annual increase
LOW " at 1.0% annual increase



NORTH ATLANTIC REGION

SELECTED OTHER PETROLEUM PRODUCTS (GASOLINE, JET FUEL, KEROSENE, DISTILLATE FUEL OIL, ASPHALTS).

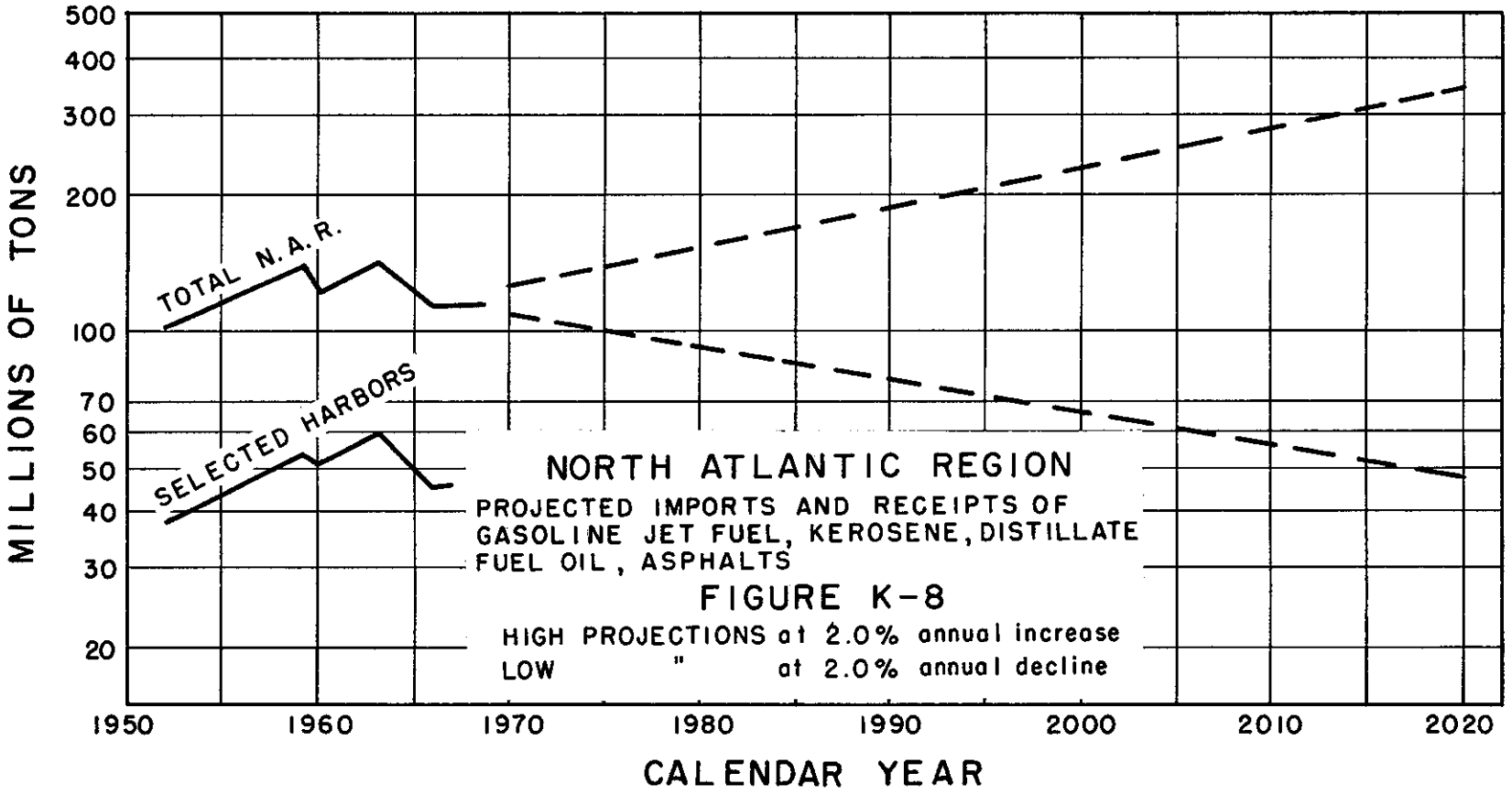
FIGURE K-7

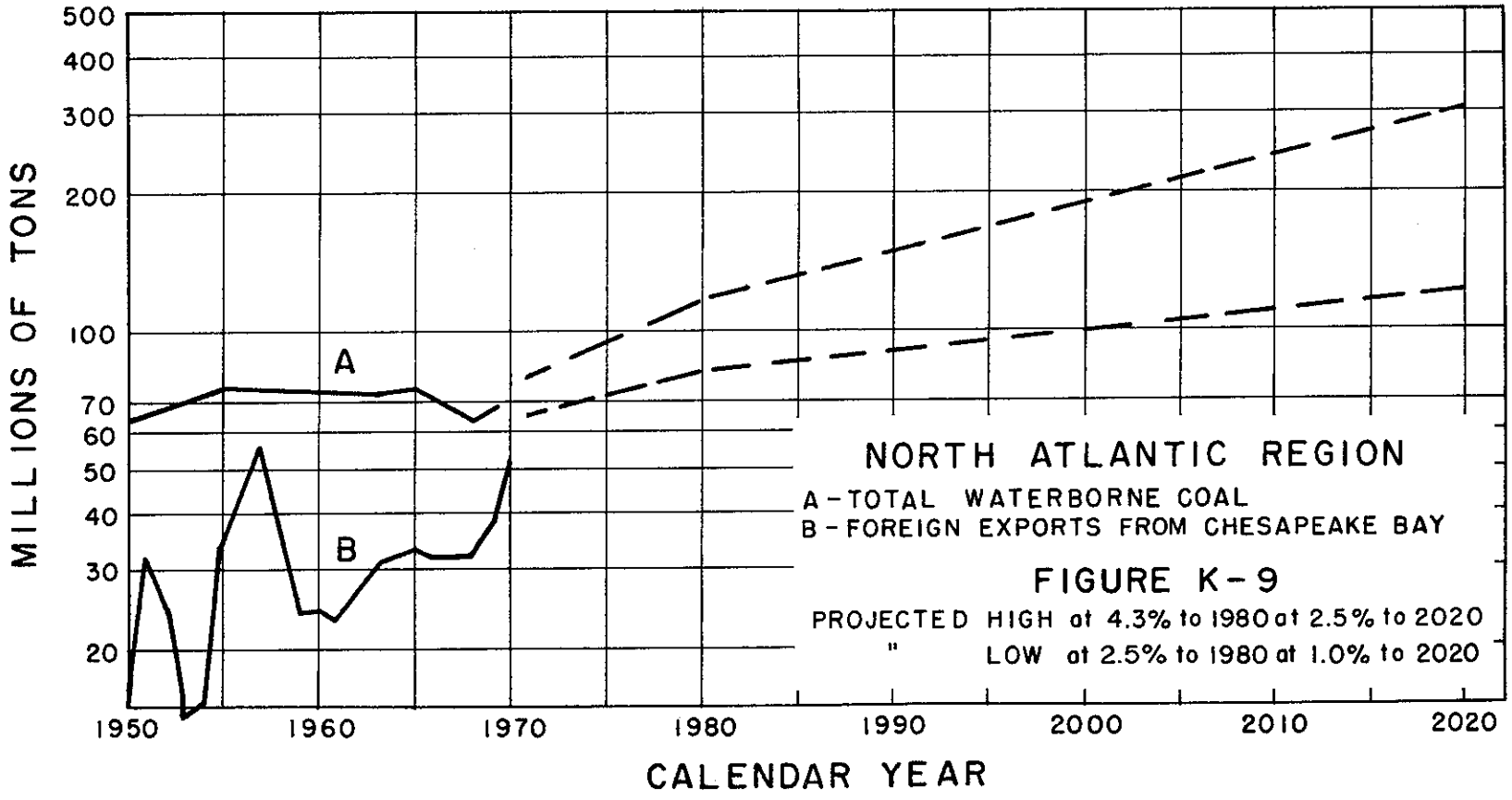
Refinery activity is the major unknown factor affecting projections. A decline in refining will certainly result in a decrease in waterborne receipts of crude petroleum, which may or may not be offset by the increase in waterborne refined receipts if pipeline capacity is increased greatly. There are varying trends for the individual commodities lumped together for the estimate shown in Figure K-8. Gasoline has exhibited a consistent increasing growth which is expected to continue, notwithstanding electric car development. Distillate fuel oil use has tapered off under competition from natural gas and electricity. A detailed analysis of the consumption patterns and trends of the individual productions is beyond the scope of this study; therefore, the products have been treated as a single commodity. Prior to completion of the Colonial Pipeline through the Region, waterborne commerce of petroleum products increased at an average annual rate of 4%. Subsequent to the construction of the pipeline, the short term decline has been almost 9% annually. It was assumed that the recent expansion of the pipeline will continue through 1972. Beyond 1972, the high range projection assumes that waterborne shipments of products will increase at 2% per annum, a slower rate than in the past, due to the moderate, continued expansion of pipelines. The low range assumes the pipelines will make inroads into waterborne shipments resulting at a somewhat slower rate of decline of 2% annually.

Coal

There are large waterborne movements of domestic coal destined both to the foreign and domestic markets. Foreign coal shipments amounted to 56 million tons in 1969, of which 67% was shipped from Sub-region F. Since 1950, U.S. exports have fluctuated significantly as shown in Figure K-9. The Korean War sparked a substantial short term growth because of stockpiling. The sharp increase in 1955 was attributed to European scarcity which was intensified by the closing of the Suez Canal in late 1956. A large coal surplus, declining business overseas, restrictive import policies, and competition from petroleum products caused the sharp decrease from 1958 to 1961. Since 1961, coal exports to Asia have shown a consistent rise due to the expanding Japanese steel industry. Almost all foreign countries now have some form of restrictive trade measures as part of a national policy to limit the degree of competition permitted between foreign and domestic energy sources. The production of European coals has generally not been sufficient to meet demands, so the United States continues to export coal to Europe.

The future outlook for U.S. coal exports will be determined, for the most part, by the trade and energy policies of the importing


MILLIONS OF TONS
500
400
300
200
100
70
60
50
40
30
20
TOTAL N.A.R.
SELECTED HARBORS
1950
1960
1970
1980
1990
2000
2010
2020
CALENDAR YEAR
NORTH ATLANTIC REGION
PROJECTED IMPORTS AND RECEIPTS OF GASOLINE JET FUEL, KEROSENE, DISTILLATE FUEL OIL, ASPHALTS
FIGURE K-8
HIGH PROJECTIONS at 2.0% annual increase
LOW " at 2.0% annual decline


500
400
300
200
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70
60
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MILLIONS OF TONS
A
B
1950
1960
1970
1980
1990
2000
2010
2020
CALENDAR YEAR
NORTH ATLANTIC REGION
A - TOTAL WATERBORNE COAL
B - FOREIGN EXPORTS FROM CHESAPEAKE BAY
FIGURE K-9
PROJECTED HIGH at 4.3% to 1980 at 2.5% to 2020
" LOW at 2.5% to 1980 at 1.0% to 2020

countries. Japan and Italy have been placing greater emphasis on long-term contracts. Some European countries will not make these commitments because of the expected establishment of a common energy policy for the European Common Market. Advantages of U.S. coal include high quality and low cost as a result of mechanized mining and available deep-draft ocean transportation facilities. Australia, Canada, the USSR, and Communist China are the major U.S. competitors. Coal export projections have been based on the report, "Export Markets for U.S. Coal," prepared in May 1965 by the Stanford Research Institute and also on a Bureau of Mines publication. They yield the high and low growth rates used to form the high and low projections of coal exports from the North Atlantic Region through 1980, as shown on Figure K-9. Because of competition expected from nuclear fuels, uncertain import restrictions, and world coal competition, coal exports are projected in increase at the slower high and low annual rates of 2.5% and 1.0% from 1980 to 2020.

General Cargo

Approximately 20 million tons of foreign waterborne general cargo moved through the NAR in 1966. Sub-regions C, D, and E are the predominant general cargo areas, presently handling 90% of the total. From 1955 to 1966, general cargo increased at an annual rate of 1.2%.

The most important general cargo trade route is between the North Atlantic Region and Europe. This route, while ranking second in terms of tonnage of the scheduled routes, leads by far in value of commercial cargo. Virtually all types of manufactured and semi-finished products, and alcoholic beverages, tobacco, and grain products, move over this route. It is felt that any discussion of prospective waterborne general cargo in the Region must be in the context of containerization. A recent study was made by the New York Port Authority to determine the volume of commerce which could be containerized. The study results show that approximately 75% of the import-export general cargo which passed through the Port of New York in 1964 was susceptible to containerization.

The factors considered in estimating this traffic included the degree of competition anticipated among steamship lines, the balance of two-way container trade, and the readiness of countries in the various trade routes for house-to-house container movements. The total potential containerized volume was projected to grow at an annual rate of 1.8% through 1975.

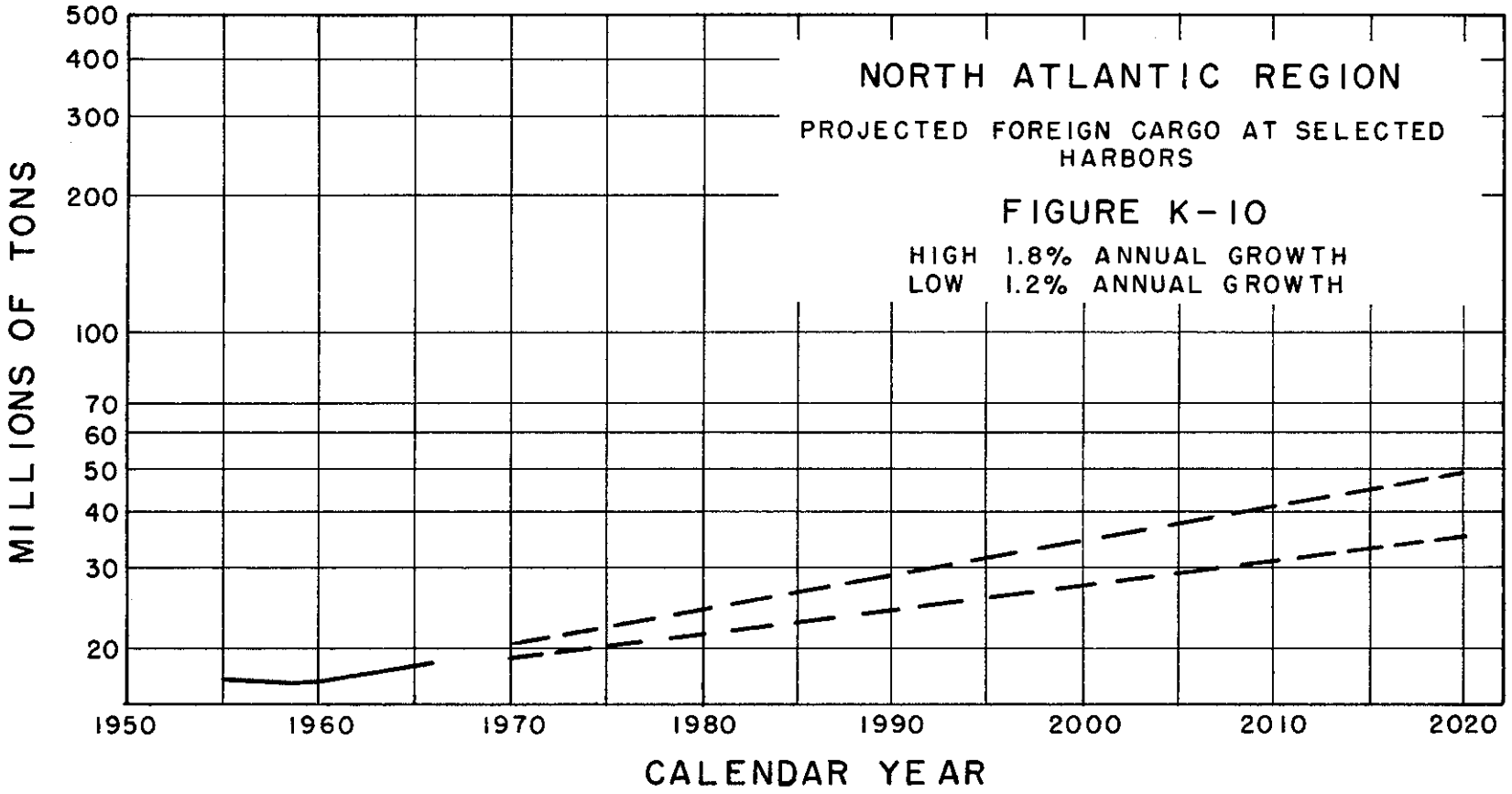
Two recent developments, although they tend to be offsetting, which could have a significant impact on future general cargo transport in the North Atlantic Region, are the rapid growth of air cargo transportation and the integration of land and sea transportation. Since the majority of air cargo will probably be confined to trade moving between industrial nations the Region will be the most seriously affected. The integration of land and sea transportation, now under

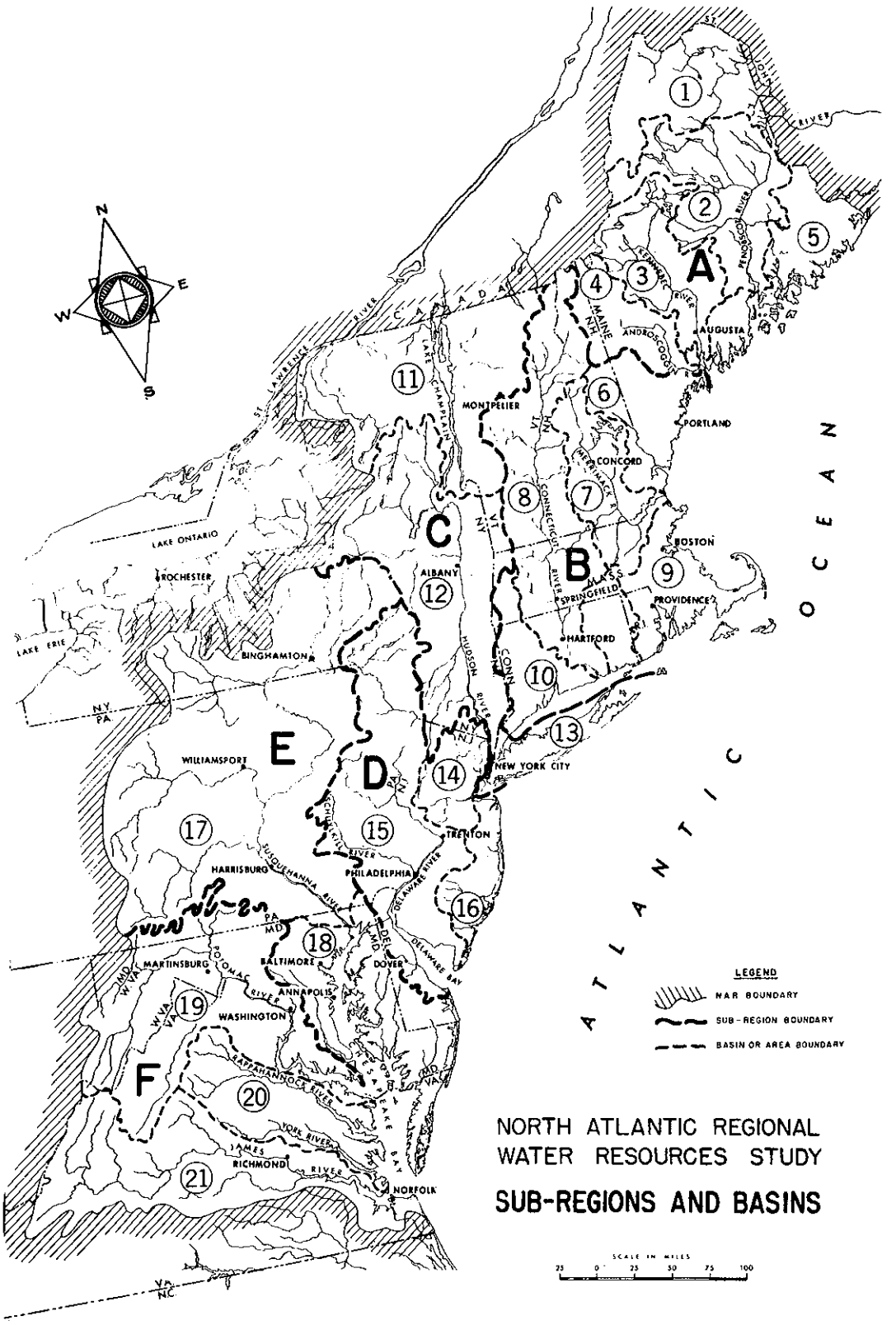
consideration by major carriers, has as its objective, speeding up the movement of international container traffic by combining high speed ground transportation with ocean travel. For example, general cargo presently moving from Japan to the Eastern Seaboard of the United States via the Panama Canal, would be rerouted through Pacific Coast ports for unit train movement across the country, saving some 10 days transit time. While this particular example also tends to reduce activity in Regional ports, the overall effect of the integration of land-sea transportation is expected to be positive since some Europe-to-Asia and Asia-to-Europe trade can be expected to pass through the United States.

Total foreign general cargo for the Region is projected to increase between a low of 1.2%, the historical trend, and a high rate of 1.8%, as projected by the New York Port Authority (Figure K-10). Foreign container traffic is estimated to be approximately 65% of the total general cargo volume in the year 2000.

RECREATIONAL BOATING

Recreational Boating tends to occur most frequently near areas of high population density. The North Atlantic Region is blessed with large water surface areas including bays behind barrier beaches, rivers and lakes close to the population centers. In the rapidly developing megalopolis extending from Washington, D.C., to Boston, boating tends to be strongly supported by private enterprise in the form of marinas with attendant parking and other facilities. As these can be very lucrative enterprises, it is anticipated that governmental activity will be primarily exerted through controls directed toward preventing the overcrowding of people on the available land and water. Public access via launching ramps and parking lots may require some governmental assistance. While access provisions are often found in conjunction with marinas, there could in fact be made a requirement for such operations where necessary to help meet this need. Many rural areas in the Region offer great potential for recreational boating on large reservoirs, lakes and rivers, but suffer from low-density use which hinders available support from private enterprise. Government will primarily exert its influence through construction of public facilities including launching ramps, comfort facilities and parking areas.


NORTH ATLANTIC REGION
PROJECTED FOREIGN CARGO AT SELECTED HARBORS
FIGURE K-10
HIGH 1.8% ANNUAL GROWTH
LOW 1.2% ANNUAL GROWTH
MILLIONS OF TONS
500
400
300
200
100
70
60
50
40
30
20
1950
1960
1970
1980
1990
2000
2010
2020
CALENDAR YEAR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14
15
16
17
18
19
20
21
CANADA
ST. LAWRENCE RIVER
LAKE CHAMPLAIN
LAKE ONTARIO
LAKE ERIE
ROCHESTER
BINGHAMTON
ALBANY
MONTPELIER
AUGUSTA
PORTLAND
CONCORD
BOSTON
SPRINGFIELD
PROVIDENCE
HARTFORD
NEW YORK CITY
WILLIAMSPORT
TRENTON
HARRISBURG
PHILADELPHIA
BALTIMORE
DOVER
ANNAPOLIS
WASHINGTON
MARTINSBURG
RICHMOND
NORFOLK
ATLANTIC OCEAN
LEGEND
MAR BOUNDARY
SUB-REGION BOUNDARY
BASIN OR AREA BOUNDARY
NORTH ATLANTIC REGIONAL
WATER RESOURCES STUDY
SUB-REGIONS AND BASINS
SCALE IN MILES
25 0 25 50 75 100

FIGURE K-11

CHAPTER 5. SUB-REGIONAL AND AREA SUMMARIES

SUB-REGION A

Commercial navigation activity is relatively minor in Sub-region A, and is expected to remain below that of the other Sub-regions throughout the planning period. Recreational boating is expected to increase moderately. However, the good ocean access and proximity to urbanized areas are offset somewhat by a lack of access to fresh water.

COMMERCIAL NAVIGATION

Sub-region A varies widely in its potential for commercial navigation development. Area 5, which is the Atlantic Coast, has many potential sites for deep-draft harbors and ports, but suffers from the Sub-region's remote location. Area 2 has some potential for commercial navigation because there are a relatively large number of people living within a few tens-of-miles of the commercially navigable waterway. The other Areas offer few opportunities.

RECREATIONAL BOATING

Potential boating water is well distributed across Sub-region A, but it varies widely in its practicality for development. Area 5 has the best and greatest access to water, although the ocean is not well suited for the most popular types of recreational boats because of its roughness and cool temperature. The other four Areas have good-sized lakes which are better suited for small craft, but generally have rather poor access. Area 1 is the most inaccessible, but many consider it to include the best boating water.

Area 1

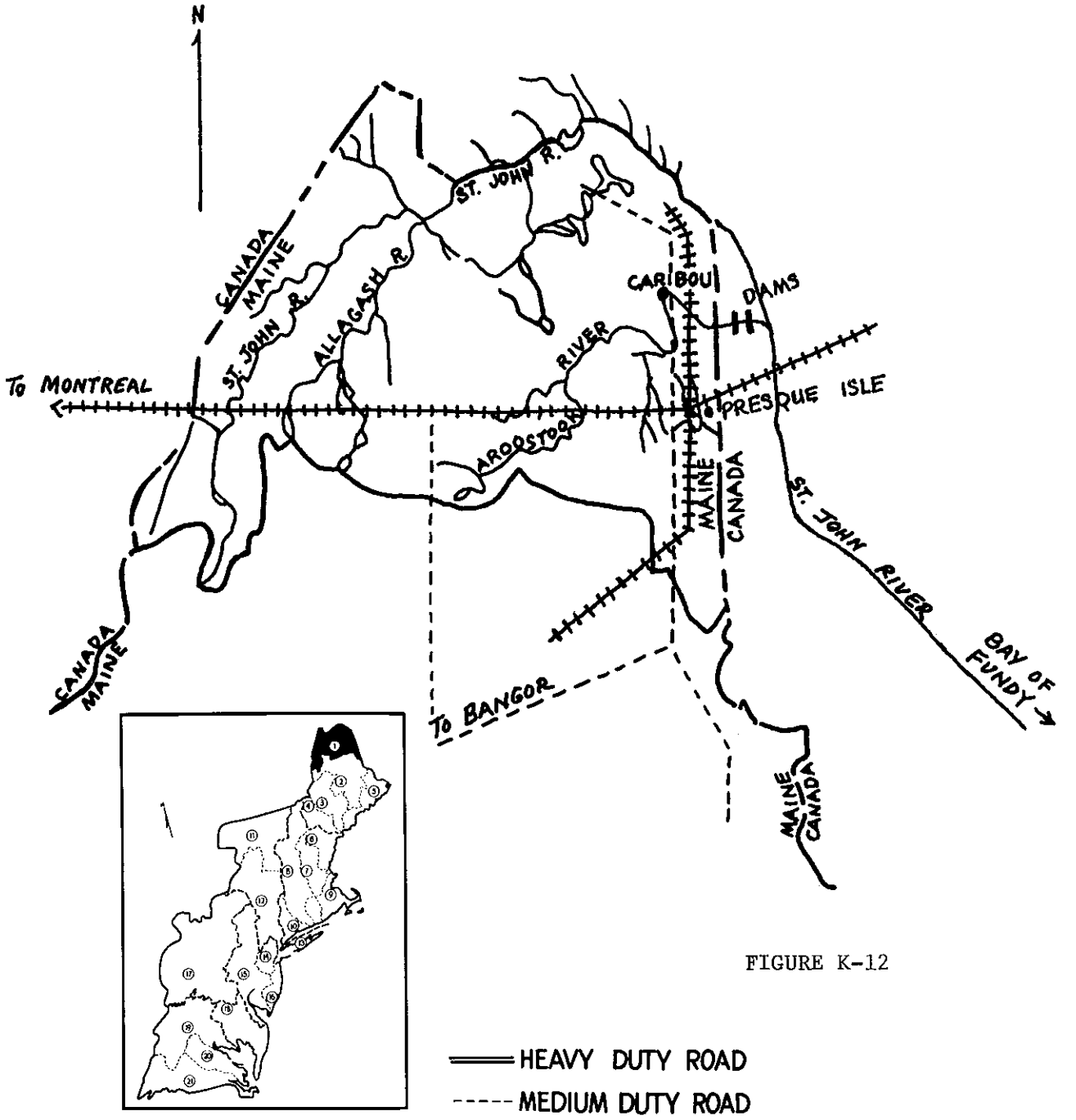


FIGURE K-12

HEAVY DUTY ROAD

MEDIUM DUTY ROAD

PRINCIPAL RAIL LINES

♦ PORTS HANDLING 1 MILLION TONS PLUS

Commercial navigation in Area 1 is negligible and little activity is expected in the next few decades. Recreation navigation activity is small, but boating is likely to grow moderately. Vector control, access and weather will be continuing problems.

Land Transportation

The existing land transportation network was evaluated as being competitive to navigation. Railroads are extensively developed in Area 1, providing access to Canada, to the urban areas of Sub-region A, and to the remainder of New England. Road networks are generally concentrated in the Area's eastern portion, and they provide for north-south movement, but are not designed for either high-speed or heavy-duty traffic. See Figure K-12.

Waterways

There are no commercially navigable waterways in Area 1. The Aroostook River is dammed at the point it meets the St. John River inside the Canadian border.

The headwaters of the St. John are in Area 1, and are very shallow with rapids and falls. As it flows through Canada 200 miles to the B y of Fundy, it gradually becomes a good-sized river which is navigable by shallow draft vessels over the last 60 miles to the Bay. There are a number of large lakes in the western portion of Area 1, but access to them is difficult. By mid-winter, ice can be expected to cover all but the fastest flowing streams.

Service Factors

Demand is generated by 110,000 people (1967), most of whom live in towns of less than 5,000 people. The major exceptions are Presque Isle and Caribou on the Aroostook River with populations of between 10,000 and 25,000 people. The population distribution is decidedly unfavorable to navigation even though concentrated in the eastern half of the Area.

The production of Area 1 is based on farming, with potatoes being the outstanding crop (1.5 million tons in 1967). Limestone, sand and gravel are produced to meet local construction needs. The Area is heavily forested and supports lumber and paper products industries. Most of these commodities are amenable to waterborne transportation, but are being transported by other common carriers, principally the railroad.

TABLE K-12
SUMMARY - AREA 1

COMMERCIAL NAVIGATION

No commercial development program appears likely.

RECREATIONAL BOATING

PROJECTED PLEASURE CRAFT

	1970	1980	2000	2020
Registered Craft*	4,500	4,700	5,500	6,500
Total Craft	8,600	10,400	15,700	22,700

*Over 10 hp.

INITIAL CAPITAL COSTS
(millions of dollars)

	1970	1980	2000	2020
Berths	--	--	--	--
Launching Facilities	--	0.1	0.2	0.2

COMMERCIAL NAVIGATION

Major Ports

St. John and Aroostook Rivers. The headwaters of the St. John River, lying within the United States, were not considered for navigation development because of current planning underway for water supply and power generation development. The St. John River has potential for navigation development up to the point in Canada that the Aroostook River flows into it. The Aroostook River is in the center of present economic development and is large enough to support shallow draft navigation once bypasses have been constructed around dams near its confluence with the St. John.

Waterborne commerce and vessel traffic have never been reported for Area 1 and shore facilities have not been constructed. No significant traffic is expected during the planning period. Therefore, no commercial development program has been proposed for waterborne commerce to the year 2020.

RECREATIONAL BOATING

The low population of Area 1 is concentrated along its eastern border. It is probable that most boating occurs here because the extensive lakes in the western portion are rather inaccessible. The launching facilities ratio of 1 to 600 was adapted from Area 6 because Area 1 is largely inland, and the lack of better information about Area 1. Boat registration in Maine averages about one registered craft per every 23 people.

Constructed facilities are expected to require public support and should include parking areas, comfort and launching facilities. Berthing was not considered because the harsh northern Maine winters tend to discourage ownership of craft requiring permanent water berthing.

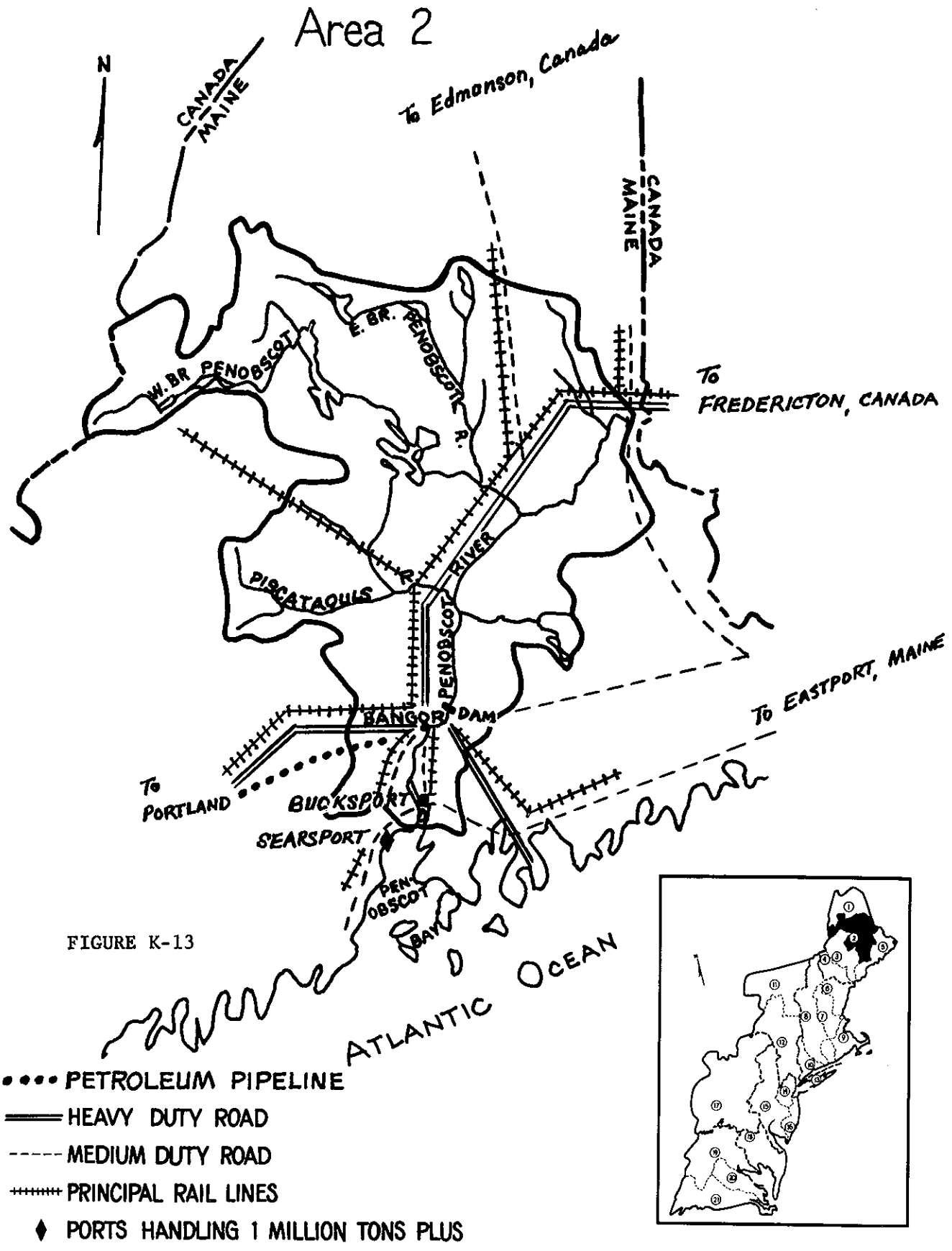

Area 2
N
CANADA
MAINE
To Edmonson, Canada
CANADA
MAINE
E. BR. PENOBSCOT R.
W. BR PENOBSCOT
To
FREDERICTON, CANADA
PISCATAQUIS R.
PENOBSCOT RIVER
BANGOR DAM
To EASTPORT, MAINE
To
PORTLAND
BUCKSPORT
SEARSPORT
PEN-
OBSCOT
BAY
ATLANTIC OCEAN
PETROLEUM PIPELINE
HEAVY DUTY ROAD
MEDIUM DUTY ROAD
PRINCIPAL RAIL LINES
PORTS HANDLING 1 MILLION TONS PLUS

FIGURE K-13

AREA 2. PENOBSCOT RIVER BASIN

Commercial and recreational navigation activity is relatively small in Area 2. Commercial navigation is limited to the lower 25 miles of the river due to dam construction just above Bangor. Physical channel constraints will inhibit future development in the upper reaches of the river. Recreational boating activity is adversely affected by poor weather, lack of road development and insect problems.

Land Transportation

The land transportation system is complementary to navigation, despite the petroleum pipeline between Portland and Bangor. As the Area map (Figure K-130) shows, Bangor is a city through which virtually all road and rail traffic passes. Highways provide the better transportation coverage along the coast, while the railroad provides better transportation coverage inland.

Waterways

From the sea to the vicinity of Bucksport there is a straight channel which is deeper than 45 feet and generally provides adequate width for the 35-foot draft vessels using the harbor in 1970. However, two rock pinnacles on the east side of the channel at a depth of 25 feet make navigation hazardous particularly during periods of strong tidal currents. Local interests maintain a 35-foot depth in a shallow reach in the vicinity of Bucksport.

The waterway between Bangor and Bucksport is crooked and narrow, but will pass a vessel of 22-foot draft at the peak of its average 11-foot tidal range. It is closed from December to May because of ice, and has periods of zero visibility during the other winter months because of land fog.

The nearest competing commercial waterways lie to the south and serve the ports of Searsport and Portland.

Service Factors

The permanent population of Area 2 is only about 150,000, and is concentrated in the southern third of the Area, mostly in the port cities. It is a popular summer resort area with seasonal populations as high as 500,000.

The production of Area 2 is based on agriculture and forestry. Their related products of lumber, dairy goods and paper are amenable to waterborne transportation, but land transportation systems successfully captured them during the 1960s.

TABLE K-13
COMMODITY DISTRIBUTION - AREA 2

		1955		1965		1968	
Total - 1000's of tons		939	100%	1,587	100%	1,516	100%
Distillate fuel oil	D/I	168	18%	432	27%	514	34%
Residual fuel oil	F/I	249	26%	529	33%	435	29%
Gasoline	D/I	228	24%	365	23%	361	24%
Misc. Petroleum	D/I	18	2%	31	2%	100	7%
Chemicals	D/I	27	3%	109	7%	91	6%
Paper	F/E	54	5%	3		4	
Other	FD/I	pulpwood coal fertilizer water		pulpwood coal fertilizer			

D = Domestic, F = Foreign, I = Import, E = Export.

The consumptive demand presently satisfied in total or part by navigation, includes chemicals for the paper industry and petroleum for industrial, domestic, and public power and heat.

COMMERCIAL NAVIGATION

Commodity Distribution

Table K-13 shows the relative importance, tonnage and trends of the commodities handled in Area 2 since 1955. The dominance of petroleum products is readily apparent.

Major Ports

Penobscot River. Bucksport has been capturing an increasingly greater amount of the total tonnage each year because of the depth limitations between Bucksport and Bangor, the poor condition of facilities at Bangor, and the trend towards larger vessels. Bucksport has good facilities with adjacent depths of 35 feet, and storage for more than 140,000 tons of petroleum products.

Waterborne commerce increased at an average annual rate of 3.3% for the 10 years prior to 1968, which is a significant decline from the 5.8% of the 19 years prior to 1968. Commerce averaged 1,628,000 tons for the three years prior to 1968. The 1970 commerce was 1,783,000 tons.

TABLE K-14
PORT SUMMARY - AREA 2 (PENOBSCOT RIVER)

PROJECTED RANGE OF WATERBORNE COMMERCE

	1970	1980	2000	2020
Millions of Tons	1.8	2.2 - 2.5	3.2 -4.8	4.6 - 9.2

DEVELOPMENT PROGRAMS

To Bucksport	1970	1980	2000	2020 1/
Channel Depth (ft)	2/	35	40	45
Improvement Cost ($millions)	-	0.3	0.5	1.0
Bucksport to Bangor				
Channel Depth (ft)	13-22	-	-	35
Improvement Cost ($millions)	-	-	-	35

1/ Alternative program - Off-loading facility near mouth of river. Estimated cost $10 million.

2/ Natural depth of 30 feet available at 600-foot width or 40 feet at 500-foot width.

The development program suggested in Table K-14 was influenced most by the overwhelming volume of petroleum products. Opportunities for improvements to Bucksport are immediately available due to the small cost of channel dredging, in the vicinity of the terminals and the two rock pinnacles, to provide a deeper channel with adequate width. Above Bucksport improvements would be considerably more costly. For this Area, improvements are not considered feasible until the latter stages of the planning period when prospective commerce may be of sufficient magnitude to support deepening.

TABLE K-15
RECREATIONAL SUMMARY - AREA 2

RECREATIONAL BOATING

PROJECTED PLEASURE CRAFT

	1970	1980	2000	2020
Registered Craft*	6,700	7,300	8,000	9,500
Total Craft	12,100	12,500	23,500	35,000

*Over 10 hp.

INITIAL CAPITAL COSTS
(millions of dollars)

	1980	2000	2020
Berths	0.1	0.2	0.4
Launching Facilities	0.4	0.4	0.4

RECREATIONAL BOATING

The Penobscot River, its tributaries, and numerous lakes provide an abundance of recreational boating opportunities in Area 2. Vessel registration averages one registered craft per 23 people. Boats less than 16 feet in length outnumber larger craft by seven to one. General publications do not include information on public boating facilities in Area 2, however, since Area 2 is geographically similar to Area 6 which had one public launching facility per 600 craft, an identical ratio was assumed for Area 2.

Costs shown for launching facilities are expected to be predominately public expenditures because of the low population density around most boating water.

Berths are expected to be constructed by private enterprise. Their most likely location will be in the southern third of Area 2, where the population is concentrated.

Commercial navigation is very small in Area 3, and is not likely to grow significantly. The Area's relatively close proximity to Portland should assure moderate growth in recreational boating.

Land Transportation

The land transportation system is strongly competitive, with commercial navigation tending to support the growth and development of nearby ports, such as Portland and Searsport, rather than those in Area 3. As can be seen from the map (Figure C-14), railroads connect Portland, Bangor, Searsport and Augusta. A modern high-speed, heavy-duty road connects Augusta with Portland and Bangor.

Waterways

The Kennebec River is dammed just above Augusta, and the portion below Augusta is divided into two parts by Merrymeeting Bay, into which the Androscoggin and Cathance Rivers also flow. Five miles below the bay is the major river port, Bath, and the junction of the Kennebec River with the Sasanoa River which causes dangerous currents. Large lakes suitable for recreational boating are scattered throughout Area 3.

The rivers and lakes above Bath are closed by ice from December to April. Bridges at Bath, Gardiner and Richmond will require extensive modification for any waterway improvement.

Service Factors

Production includes food, dairy products, textiles, lumber and paper which at their present production volume, have only marginal potential support for navigation. Consumption consists of iron and steel products required for the shipbuilding industries at Bath. However, trends indicate that this industry is declining.

Demand is generated by a resident population of about 150,000, 40% of which is located along the navigable portion of the waterway. There is a slight seasonal fluctuation of population due to tourists.

COMMERCIAL NAVIGATION

Major Ports

Kennebec River. The Kennebec River is generally 30 feet deep and 500 feet wide to Bath, and experiences a tide range greater than 9 feet. Above Bath, maintenance is required to stabilize a channel, 150

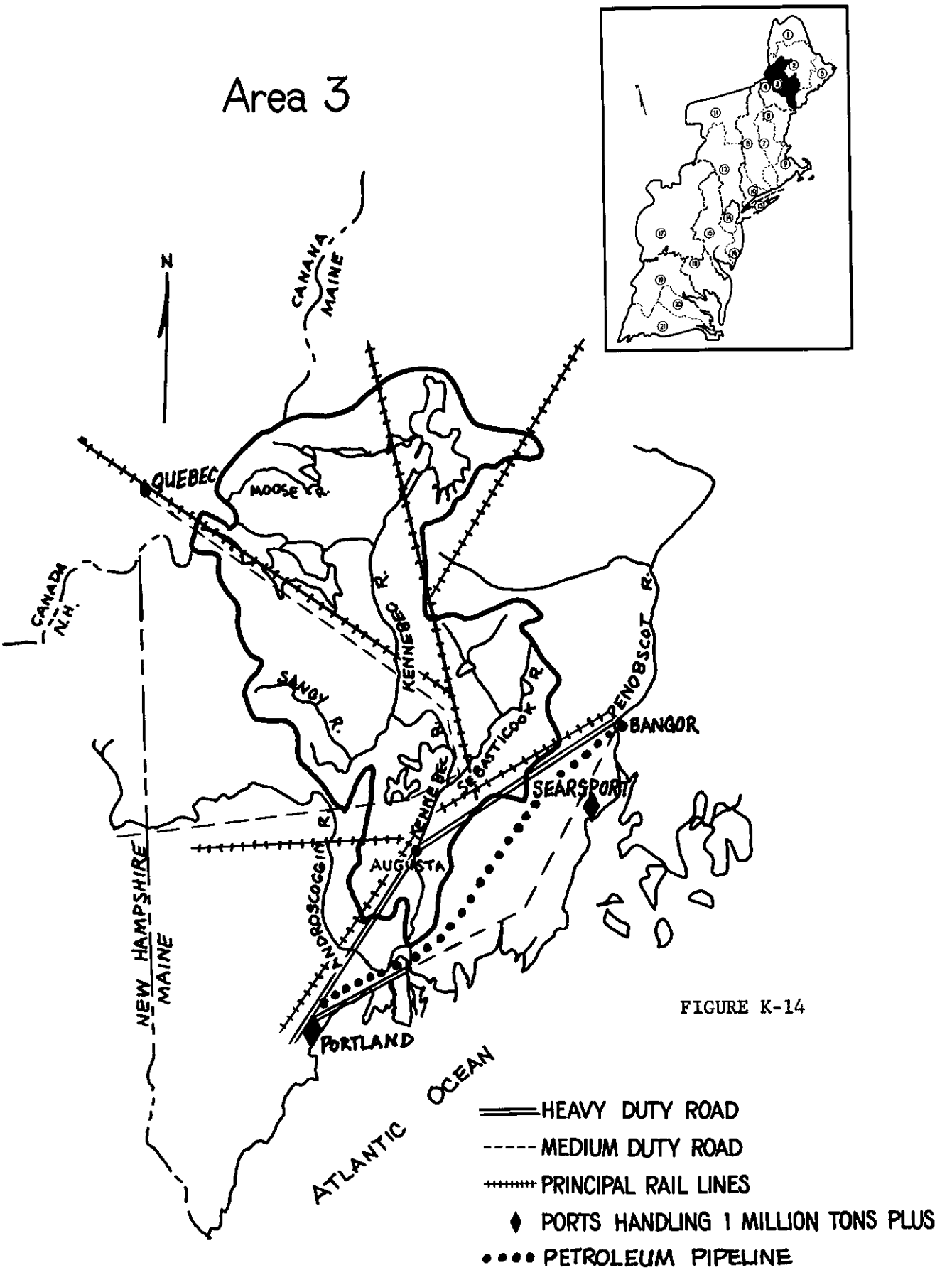

Area 3
N
CANADA
MAINE
QUEBEC
MOOSE R.
CANADA
N.H.
SANDY R.
KENNEBEC R.
PENOBSCOT R.
BANGOR
SEARSPORT
SEBASTICOOK R.
KENNEBEC R.
AUGUSTA
ANDROSCOGGIN R.
NEW HAMPSHIRE
MAINE
PORTLAND
ATLANTIC OCEAN
HEAVY DUTY ROAD
MEDIUM DUTY ROAD
PRINCIPAL RAIL LINES
PORTS HANDLING 1 MILLION TONS PLUS
PETROLEUM PIPELINE

FIGURE K-14

TABLE K-16
SUMMARY - AREA 3

COMMERCIAL NAVIGATION

PROJECTED RANGE OF WATERBORNE COMMERCE

	1970	1980	2000	2020
Millions of Tons	0.03	0.04-0.06	0.08-0.12	0.1-0.2

DEVELOPMENT PROGRAM

No program for commercial navigation appears likely.

RECREATIONAL BOATING

PROJECTED PLEASURE CRAFT

	1970	1980	2000	2020
Registered Craft*	6,800	7,200	8,100	9,300
Total Craft	12,500	16,900	39,500	65,000

*Over 10 hp.

INITIAL CAPITAL COSTS
(millions of dollars)

	1970	1980	2000	2020
Berths	--	0.1	0.2	0.3
Launching Facilities	--	0.1	0.4	0.8

feet wide and 17 feet deep to Gardiner; and 125 feet wide and 11 feet in depth to Augusta. Channel maintenance has not been required since the mid-1960s.

Commerce underwent an average annual decline of 25% from 1958 to 1968. Prior to 1963, when tonnage averaged more than 100,000 tons annually, coal and petroleum accounted for 97% of the reported tonnage. Commerce in 1970 was 3,300 tons, evenly distributed among fish and fuel oil. Presently, fishing vessels with drafts of about 7 feet constitute most of the traffic.

Prospective commerce through the year 2020 is not expected to exceed 200,000 tons. Existing channels properly maintained are expected to be able to efficiently accommodate barges and other shallow-draft vessels expected to use the waterway. Therefore, no commercial development program has been proposed for Area 3.

RECREATIONAL BOATING

Available information concerning the public facilities along the Kennebec River below Augusta, indicates that there are about 170 permanent moorages or slips and six launching facilities. Surveys conducted by the Corps of Engineers in the early 1960s, determined that about 300 vessels regularly used the waterway along that portion. As those vessels constituted less than 2% of the total craft estimated to be in Area 3, the ratio of facilities to craft they suggest has been ignored. The ratio of 1 to 600 from Area 6 was utilized to estimate needed facilities for Area 3.

Launching facilities costs shown are expected to require public participation because of the extremely low population density of this Area.

AREA 4. ANDROSCOGGIN RIVER BASIN

Prospects for any commercial navigation in the Androscoggin Basin are small. Growth in recreational boating will depend to a large extent on complementary road development and vector control.

Land Transportation

As shown on the map (Figure K-15), rail and highway development covers the Area thoroughly. Land transportation is evaluated as competitive to navigation, because of the direct connections between Portland and Lewiston.

Waterways

At high tide, the Androscoggin will pass vessels of 5-foot draft up as far as Brunswick and Topsham. The tide range averages 3 to 5 feet. There are numerous large lakes in the northern portion of the Area, and ice closes most waterways between December and May.

Service Factors

The permanent population of Area 4 is about 140,000, however, less than one-quarter live along the lower 20 miles of the Androscoggin.

Neither commercial consumption nor production is considered to support navigation.

COMMERCIAL NAVIGATION

Major Ports

Androscoggin River. The Androscoggin River is quite narrow and shallow, and at high tide, vessels of 5-foot draft can pass as far as Brunswick, about 8 miles from the Androscoggin's junction with the Kennebec River in Merrymeeting Bay. No commerce has been reported on this river and no significant commerce is foreseen. Therefore, no commercial development program is proposed for Area 4.

RECREATIONAL BOATING

The Androscoggin is crooked, narrow and very shallow. Since the discontinuation of river driving and storage of logs, the Androscoggin has been rediscovered by more and more small-craft boating enthusiasts. Specifically, the section north of Berlin, New Hampshire, lends itself to

Area 4

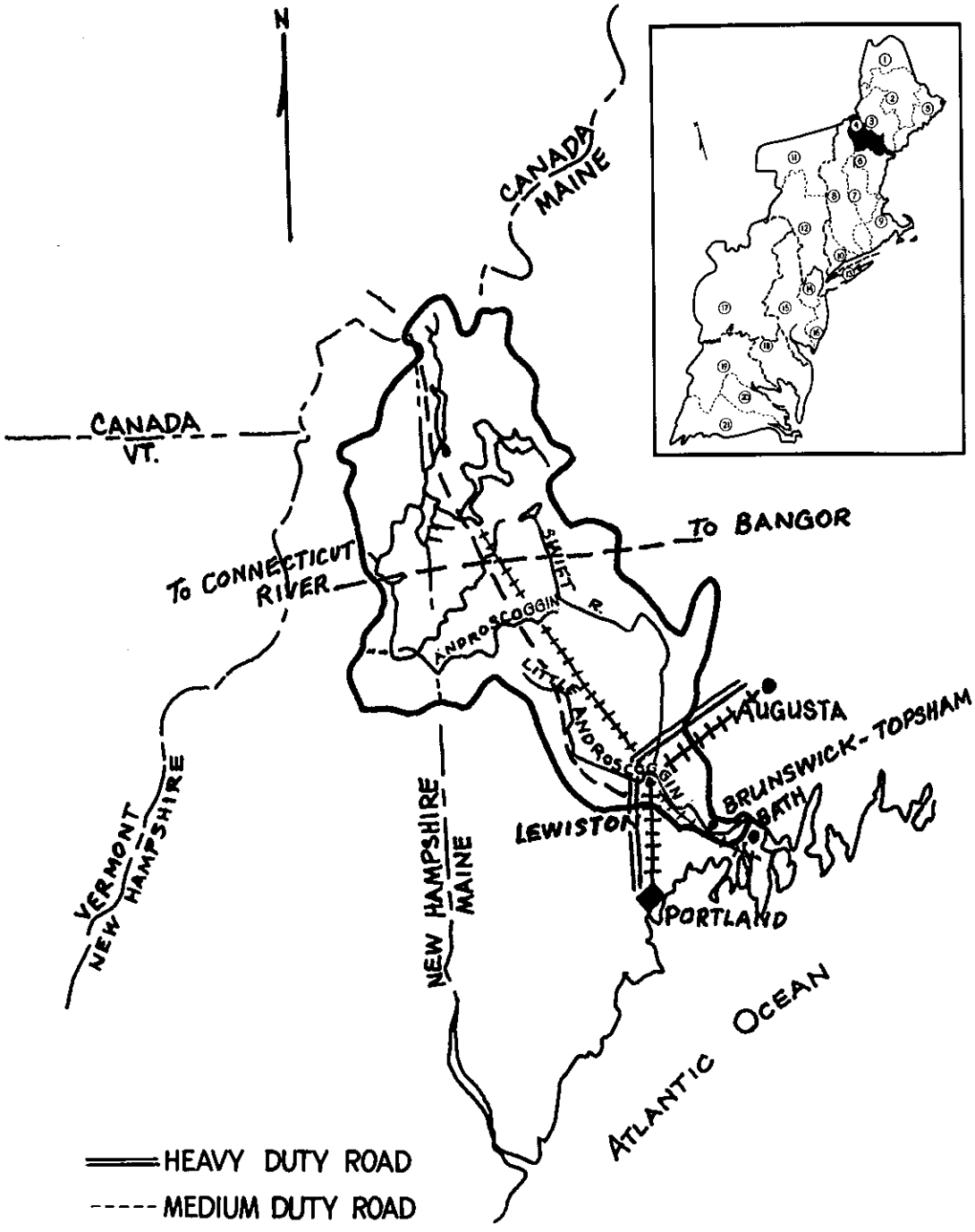


FIGURE K-15

TABLE K-17
SUMMARY-AREA 4

COMMERCIAL NAVIGATION

No commercial development program appears likely.

RECREATIONAL BOATING

PROJECTED PLEASURE CRAFT

	1970	1980	2000	2020
Registered Craft*	6,000	6,300	6,800	8,000
Total Craft	11,000	12,000	18,600	27,000

*Over 10 hp.

INITIAL CAPITAL COSTS
(millions of dollars)

	1980	2000	2020
Berths	0.1	0.1	0.3
Launching Facilities	--	0.2	0.3

canoeing because of varying degrees of rapids, including white water. This section, moreover, provides an interesting, meandering setting, beautiful yet wild, and is easily accessible. Inland lakes also provide extensive opportunities to meet recreational needs. Prospective boats and initial capital costs for recreational boating are shown in Table K-17. Moderate public participation is expected to be required to provide berths and launching facilities.

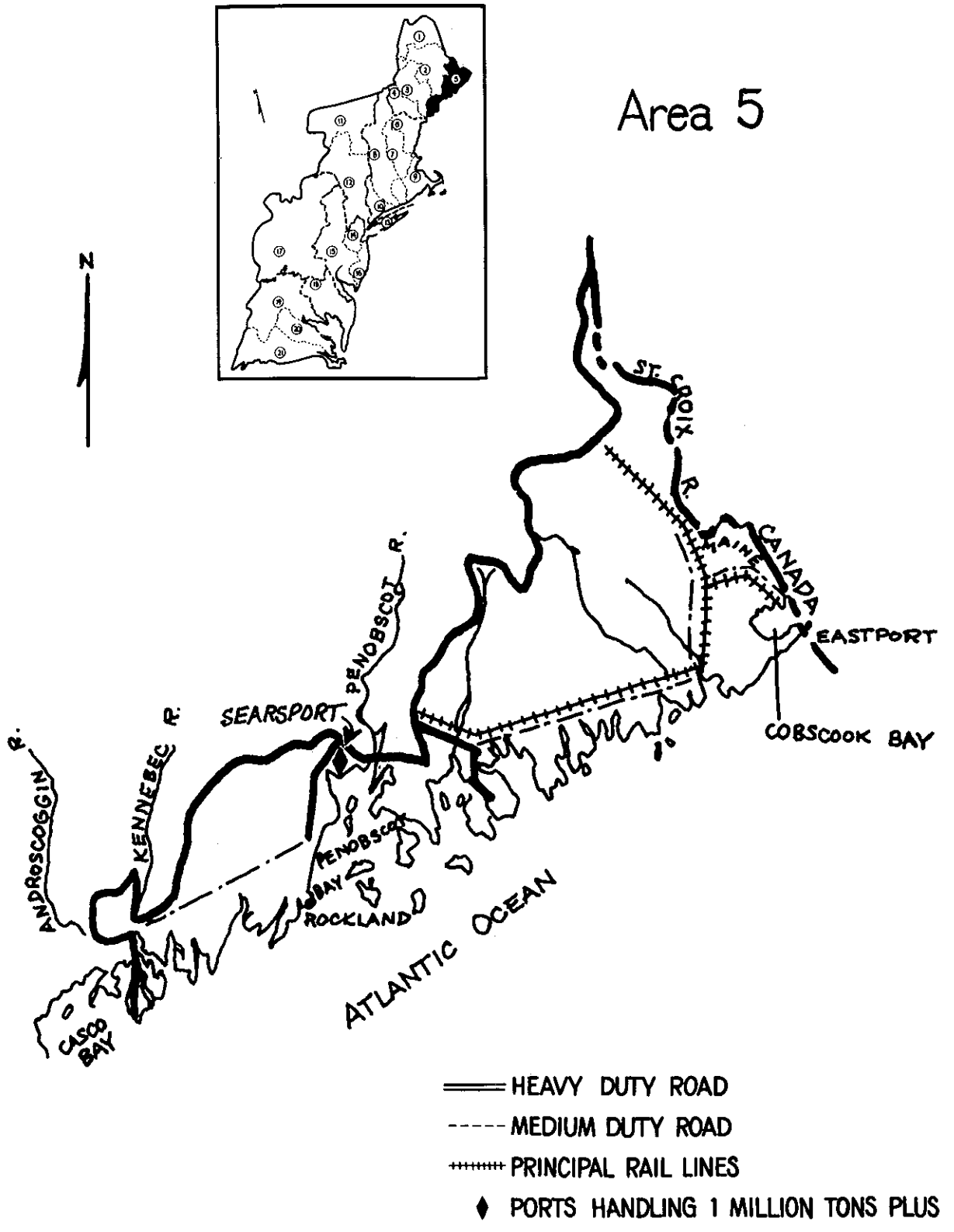

Area 5
N
ST. CROIX R.
MAINE
CANADA
EASTPORT
COBSCOOK BAY
PENOBSCOT R.
SEARSPORT
KENNEBEC R.
ANDROSCOGGIN R.
PENOBSCOT BAY
ROCKLAND
ATLANTIC OCEAN
CASCO BAY
HEAVY DUTY ROAD
MEDIUM DUTY ROAD
PRINCIPAL RAIL LINES
PORTS HANDLING 1 MILLION TONS PLUS

FIGURE K-16

AREA 5. MAINE COASTAL BASINS

Commercial navigation, although relatively small at present, has good potential for growth in Area 5 because of its deep natural harbors. Steady growth in recreational boating should occur because of the relatively good access to the coast.

Land Transportation

The land transportation network is neither strongly competitive nor complementary to navigation. While it provides good lateral movement along the coast, it does not support movement inland to any significant degree except along the St. Croix River at the eastern boundary of the Area. The highways are capable of handling heavy-duty traffic, but are not designed for high-speed traffic. The rail and highway system closely parallel each other. (See Figure K-16).

Waterways

Waterway development has not included much river channel improvement because only small, short rivers drain Area 5. Development has primarily consisted of providing service channels between shore facilities and the appropriate offshore depth contour. The coastline is highly irregular with numerous areas where depths of 30 to 100 feet can be found within a mile from shore.

There are 10 very large bays with depths naturally deeper than 40 feet, none of which are now used for navigation because of their isolated location with respect to population concentrations and highways or railroads.

Service Factors

Commercial production has the potential to strongly complement navigation, but land transportation has successfully competed for commercial transportation since 1955. Hundreds of thousands of tons of fertilizer, concrete, zinc and copper are produced annually in the vicinity of Penobscot Bay. Seafood canning and agriculture are activities which have barely utilized navigation. Commodity demand is generated by 160,000 people with half concentrated around Penobscot Bay and half spread thinly along the coast in communities of no more than a few thousand people.

Commercial consumption includes chemicals for the paper industries of adjacent Areas, and petroleum products, including jet fuel. Central Maine Power Company is completing an 800 MW Yankee Atomic

TABLE K-18
COMMODITY DISTRIBUTION - AREA 5

		1955		1965		1968	
Total - 1000's of tons		1,170	100%	1,570	100%	1,290	100%
Residual fuel oil	F/I	258	22%	680	43%	571	44%
Jet fuel	D/I	54	4%	374	24%	154	12%
Salt	F/I			40	2%	121	9%
Fish	D/E	77	7%	38	2%	88	7%
Distillate fuel oil	D/I	74	6%	86	6%	81	6%
Gasoline	D/I	157	13%	82	5%	68	5%
Chemicals	D/I	22	2%	52	5%	50	4%
Coal	D/I	263	22%	28	3%	41	3%
Vegetables	F/I	11	1%	31	2%	28	2%
Pulp	F/E	12	1%	16	1%	24	2%
Paper	F/E	53	4%	11	1%		
Rock	F/I	23	2%	15	1%	24	2%
Other	D/I or D/E	ores (E) animal feed cement (E) fertilizer		ores (E) animal feed		ores (E) sugar	

F = Foreign, D = Domestic, I = Import, E = Export.

plant at Wiscasset along the Sheepscot River. This may result in consideration of Wiscasset as an alternative or auxiliary port for future commerce.

COMMERCIAL NAVIGATION

Commodity Distribution

Table K-18 shows the recent relative importance, volume and trends of waterborne commodities in Area 5.

Major Ports

Searsport. Searsport, the most important harbor in Area 5, is located at the head of Penobscot Bay, which has an average depth over 60 feet. About a mile separates the harbor facilities from the deep water of the bay, and the 35-foot access channel experiences a 10-foot average daily tide range. Rock ledges in the vicinity of the harbor are marked by buoys.

Very little of the vessel traffic has been reported to have utilized the tide, which suggests that the waterway is adequate at present.

TABLE K-19
PORT SUMMARY - SEARSPORT

PROJECTED RANGE OF WATERBORNE COMMERCE

	1970	1980	2000	2020
Millions of Tons	1.0	1.2-1.4	1.7-2.6	2.4-5.1

DEVELOPMENT PROGRAM

	1970	1980	2000	2020
Channel Depth (ft)	35	-	40 1/	45 1/
Improvement Cost ($millions)	-	-	6	8

1/ Alternative program - Offshore terminal as alternative to channel dredging. Estimated cost $6 million.

Four piers, which are equipped to handle petroleum products and store up to 650,000 barrels, are the basic port facilities. There is open and covered storage for other cargos, and access to the railroad network.

Commerce averaged a 3.3% annual rate of growth in the 10 year period from 1958 to 1967, which is a decline from the 6% rate of the 19 years prior to 1968. The average for the three years prior to 1968 was 1,250,000 tons. The 1970 commerce was 1,010,000 tons. The projected annual tonnage shown in Table K-19 reflects a minimum growth of 1.8 percent and a maximum rate of 3.3 percent.

The consideration behind the programs suggested in Table K-19 was the large anticipated volume of petroleum products which would result in the movement of increasingly larger tankers in the Area.

Rockland. Rockland is one of many shallow-draft harbors along Penobscot Bay, and its facilities are better than average. It lies in a natural bight protected by breakwaters, and while the natural depths lie between 12 and 18 feet, a 13-foot minimum depth is maintained. Facilities include 13 wharves supported by railroad connections and small boats and vessel repair facilities that serve both fishing and recreational fleets.

Rockland's waterborne commerce shows an average rate of decline of about 1% over the 19 years prior to 1968. Commerce averaged 90,000 tons for the three years prior to 1968. The 1970 commerce was about 30,000 tons reflecting a continuing decline.

TABLE K-20
PORT SUMMARY - ROCKLAND AND EASTPORT-COBSCOOK BAY

PROJECTED RANGE OF WATERBORNE COMMERCE

	1970	1980	2000	2020
Millions of Tons	0.07	0.07-0.1	0.1-0.2	0.15-0.3

DEVELOPMENT PROGRAMS

No commercial development program appears likely.

Commerce projections for Rockland are included in the projections for Eastport-Cobscook Bay, which are shown above. No development programs have been suggested for this harbor, because its present facilities and depths can adequately handle the projected tonnage.

Eastport-Cobscook Bay. Cobscook Bay is almost inclosed by land, and Eastport ranks first among its half dozen ports. Eastport and Cobscook Bay can both be reached by Lubec Channel, Quoddy Roads or Head Harbor Passage.

Lubec Channel is a short cut through rock which can pass vessels of 12-foot draft, shaving 11 miles from the alternative routes to Eastport or the Bay. The longer passages are as deep as 50 feet. Eastport has offshore depths of about 35 feet and the Bay proper is about 14 feet deep.

Most of the commerce for Cobscook Bay passes through Lubec Channel. Waterborne commerce fluctuated so greatly over the 19 years prior to 1968, that the historical growth rate is meaningless. Commerce averaged 75,000 tons for the three years prior to 1968. The 1970 commerce was 36,000 tons. No improvements have been suggested for this harbor as present facilities and channels can adequately handle projected commerce.

RECREATIONAL BOATING

Recreational boating will certainly have a major impact on the economy of Area 5, despite the fact that water temperatures are very chilly all year round. Craft used on the ocean tend to be larger than those used on fresh water. As craft size increases, it is less convenient to trailer from place to place. Therefore, berthing is expected to be more widely developed in Area 5 than in the other Areas of Sub-region A.

TABLE K-21
SUMMARY - AREA 5

COMMERCIAL NAVIGATION

PROJECTED RANGE OF WATERBORNE COMMERCE

	1970	1980	2000	2020
Millions of Tons	1.07	1.27-1.5	1.8-2.8	2.55-5.4

INITIAL CAPITAL COSTS 1/

	1980	2000	2020
Millions of Dollars	--	6	8

1/ Costs shown are for channel deepening. Alternative program of offshore facility has an estimated cost of $6 million.

RECREATIONAL BOATING

PROJECTED PLEASURE CRAFT

	1970	1980	2000	2020
Registered Craft*	7,000	7,600	8,900	10,500
Total Craft	13,000	15,500	24,400	32,500

*Over 10 hp.

INITIAL CAPITAL COSTS
(millions of dollars)

	1980	2000	2020
Berths	0.1	0.3	0.4
Launching Facilities	0.1	0.3	0.3

At present, there are 108 public marinas in the vicinity of Penobscot Bay, including 800 permanent slips or moorages, 25 marine railroads capable of handling craft up to 250 tons, and 10 launching facilities. Most of the recreational boating will be concentrated in Penobscot Bay for the foreseeable future, because it is relatively well-protected with numerous islands and public parks.

It is expected that private enterprise will be able to satisfy the demand for berthing, but public assistance will be necessary to provide adequate launching facilities.

TABLE K-22
SUMMARY - SUB-REGION A

COMMERCIAL NAVIGATION

PROJECTED RANGE OF WATERBORNE COMMERCE

	1970	1980	2000	2020
Millions of Tons	2.9	3.5-4.1	5.1-7.7	7.3-14.8

INITIAL CAPITAL COSTS 1/

	1980	2000	2020
Millions of Dollars	0.3	6.5	9.0

1/ Costs shown are for channel improvements. Alternative program of off-loading facilities in Areas 2 and 5 has estimated costs of $10 million and $6 million, respectively.

RECREATIONAL BOATING

PROJECTED PLEASURE CRAFT

	1970	1980	2000	2020
RegisteredCraft*	31,000	33,100	37,300	43,800
Total Craft	57,200	67,300	121,700	182,900

*Over 10 hp.

INITIAL CAPITAL COSTS
(millions of dollars)

	1980	2000	2020
Berths	0.4	0.8	1.4
Launching Facilities	0.7	1.5	2.0

SUB-REGION B

This Sub-region is second in commercial navigation activity in the North Atlantic Region. Portland and Boston are the major centers of shipping and are expected to maintain their relative standing throughout the planning period. Recreational boating activity is high near the more urbanized areas of Connecticut, Rhode Island and Massachusetts, and strong growth is expected.

COMMERCIAL NAVIGATION

Areas 6 and 9 offer the greatest potential in Sub-region B for continued commercial navigation development because of good harbor areas, highly complementary land transportation development and a very large tributary population. Area 10 also offers potential but is somewhat constrained due to lack of comparatively good harbors or complementary land transportation development. Areas 7 and 8 offer significantly less potential.

RECREATIONAL BOATING

Areas 8, 9 and 10 offer great potential for recreational boating. Area 8 is the Connecticut River Basin, which is suitable for extensive fresh water boating and excellently located with respect to population centers. Area 9 has tremendous ocean frontage with excellent access which is generally well protected by long bays and capes. Area 10 is adjacent to Long Island Sound, which has a large potential for recreational development. Areas 6 and 7 offer less potential.

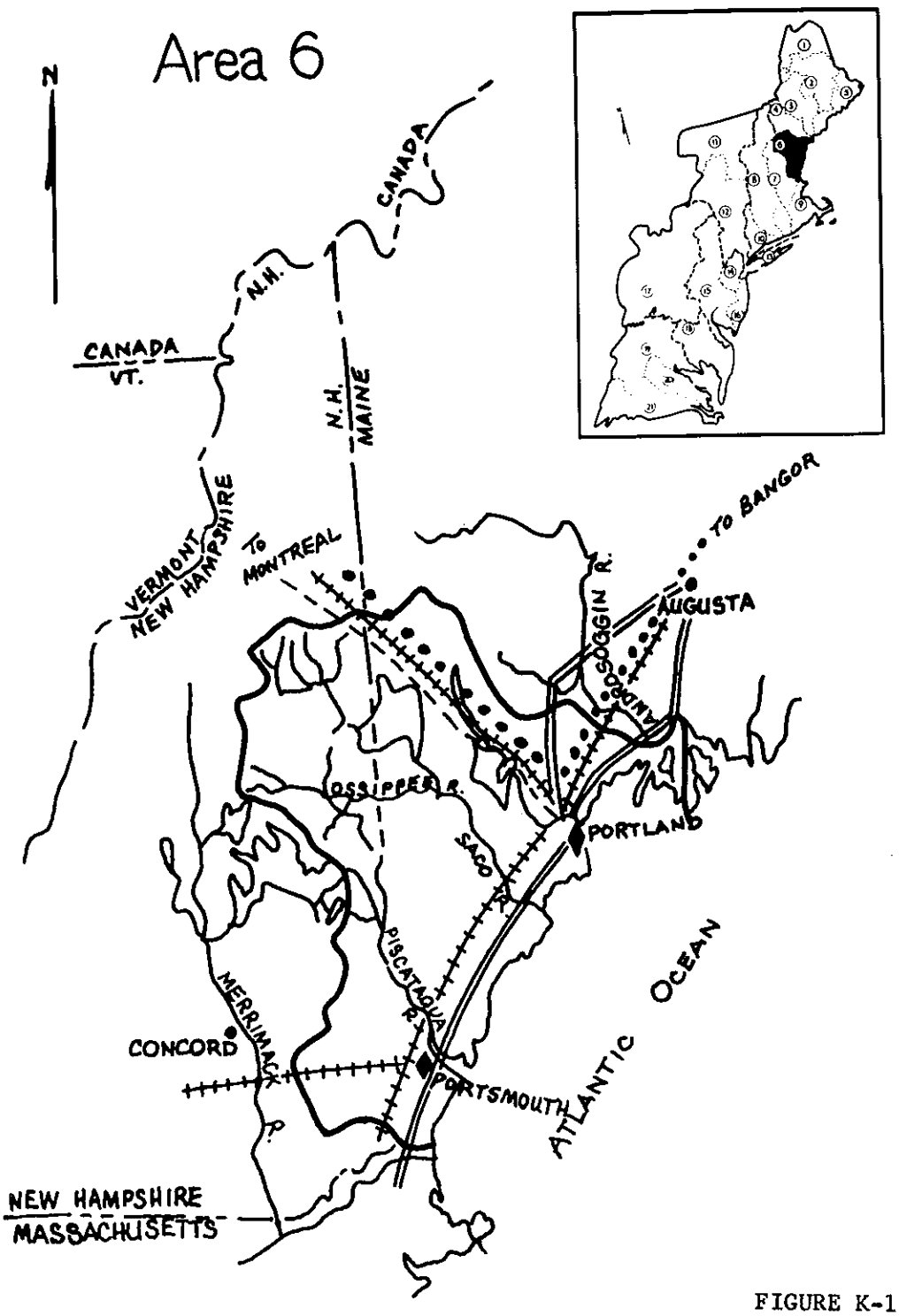


FIGURE K-17

HEAVY DUTY ROAD

MEDIUM DUTY ROAD

PRINCIPAL RAIL LINES

♦ PORTS HANDLING 1 MILLION TONS PLUS

PETROLEUM PIPELINE

AREA 6. SOUTHERN MAINE AND COASTAL NEW HAMPSHIRE

Relatively high commercial navigation activity occurs on the coastal waters of this Area, principally in the vicinity of Portland. Growth in the handling of petroleum, the major commodity, is uncertain because of competition from other Areas. Recreational boating is about evenly divided between coastal and inland waters, with much of the activity generated by out-of-Area residents. Pollution and overcrowding problems could inhibit growth to some extent.

Land Transportation

The map of Area 6 (Figure K-17) shows that a rather good radial transportation system has developed around Portland, and land transportation is extremely complementary to the port. However, land transportation serving Portsmouth is anything but complementary, and serves to support the diversion of Portsmouth's waterborne commerce to either Boston or Portland.

The pipelines extending between Portland and Montreal are used to transship crude petroleum to Canada.

Waterways

Most of the ports, harbors and marinas in Area 6 are located near the mouths of rivers, or in relatively sheltered coastal bights. Few of the rivers are navigable more than 8 miles inland although they experience a 9-foot tide range.

Except for Portland and Portsmouth, which are discussed later, access waterways have generally been designed for the vessels with maximum drafts of about 8 feet.

The major inland waterways are lakes. Sebago Lake, the largest, covers about 20 square miles.

Service Factors

Production in Area 6 is not very favorable to navigation. Textiles, meat and some dairy products are high-value commodities which, while susceptible to containerization, have been transported to their domestic markets by land transportation for some time. A similar situation exists in regard to the paper, sand, and gravel produced in Area 6.

TABLE K-23
COMMODITY DISTRIBUTION - AREA 6

		1955		1965		1968	
Total - 1000's of tons		15,400	100%	19,100	100%	29,000	100%
Crude petroleum	F/I	10,351	67%	12,627	63%	21,500	74%
Distillate fuel	D/I	409	3%	1,739	9%	2,366	8%
Residual fuel oil	F/I	749	5%	2,608	13%	2,381	8%
Gas/Kerosene/Jet Fuel	D/I	1,795	12%	2,600	13%	2,459	9%
Coal	D/I	604	5%	149	1%		
Wheat	F/E	76		24			
Fish	L	43		23		25	
Salt	F/I			37		104	
Pulp	F/I	43		25		4	
Clay	F/I	73		38		27	
Paper	F/E	35					

F = Foreign, D = Domestic, L = Local, I = Import, E = Export.

Industrial consumption satisfied in part by navigation, includes only petroleum products.

Commodity demand is generated by 457,000 people, 40% of whom are located in the vicinity of Portland and 40% in the vicinity of Portsmouth. The remaining 20% are located in small communities scattered throughout the Area.

COMMERCIAL NAVIGATION

Commodity Distribution

Table K-23 shows the recent relative importance and the volume and trends of the waterborne commodities in Area 6.

The crude petroleum listed in Table K-23 is not included in the Nation's crude oil import allowance because it is transshipped to Canada. Crude petroleum has been exclusively handled at Portland.

Major Ports

Portland. At Portland, an inner and outer harbor have been developed on the southern coast of Casco Bay. The inner harbor is located along the Fore River, which has been improved to provide for vessel traffic of 35-foot draft. The 49 facilities of the inner harbor are supported by covered storage (460,000 square feet), petroleum storage (700,000 tons), grain elevators, cold storage, shore-based hoisting equipment and waterfront repair facilities, including dry docks. Most of the facilities are served by rail spurs and improved

roads. The outer harbor is protected by islands in the Bay. A channel, 1,000 feet wide and 45 feet deep, provides access to the outer harbor from the deep water of the Bay. The outer harbor's five facilities are supported by petroleum storage (500,000 tons).

Three pipelines are used for pumping crude petroleum to Canada, and a fourth to Bangor is used for refined products.

Waterborne commerce increased at an average annual rate of 5.0% over the 19 years prior to 1968. Commerce averaged 21,198,000 tons for the three years prior to 1968. The 1970 commerce was 30,000,000 tons. The projected maximum annual growth rate in Table K-24 from 1970 to 1980 is 5%. Thereafter, growth is expected to slow due to economic and physical constraints.

The most important aspect of the projected commerce of Table K-24 upon which Area 6's development programs are based, is that planning in the United States may have no effect on Canadian crude oil petroleum demand. Impacts of commercial navigation on environmental quality should be given detailed consideration in any future planning.

Portsmouth. Portsmouth is located two miles from the Atlantic Ocean on the Piscataqua River. The river channel has been improved to a depth of 35 feet, with an average width of 400 feet (one-way traffic) for a distance of 6 miles. In the mouth of the river, natural depths of 68 feet are available for anchorage. Special anchorages and channels 6 feet deep serve the shallow-draft vessel fleets. There are 7 facilities in the 4 miles above Portsmouth which are specialized to handle petroleum products and supported by petroleum storage (250,000 tons). Thirteen of the 14 facilities at Portsmouth do not have depths greater than 25 feet. The remaining facility, which has 15 acres of open storage used for general cargo, has 35-foot adjacent depths and is served by rail spurs and good roads. Bridges at Portsmouth restrict the channel width to 200 feet with 135 feet of vertical clearance. Rock ledge was removed to achieve the present depth.

Waterborne commerce at Portsmouth increased at an annual rate of 4.8% from 1949 to 1967. However, its annual growth in the 10 years from 1958 to 1967 was only 4.9%. Commerce averaged 1,740,000 tons for the three years prior to 1968. The 1970 tonnage was 2,190,000 tons.

RECREATIONAL BOATING

The remaining harbors of Area 6 are generally used by vessels of 7- to 9-foot drafts. While some of the vessels are tank barges and commercial fishing craft, the majority are recreational boats. Since both types of vessels of similar drafts can use the same harbors, there will be no effort to distinguish between them. A cove just north of Portland has been developed exclusively for recreational craft.

TABLE K-24
PORT SUMMARY - PORTLAND

PROJECTED RANGE OF WATERBORNE COMMERCE

	1970	1980	2000	2020
Millions of Tons	30.0	37-49	61-80	96-120

DEVELOPMENT PROGRAMS

	1970	1980	2000	2020
Portland Harbor - House Island Anchorage				
Channel Depth (ft)	45	50+	60+	-
Improvement Cost ($ millions)	-	30	100	-
Portland Harbor - Fore River				
Channel Depth (ft)	25	40	45	-
Improvement Cost ($ millions)	-	20	20	-

TABLE K-25
PORT SUMMARY - PORTSMOUTH

PROJECTED RANGE OF WATERBORNE COMMERCE

	1970	1980	2000	2020
Millions of Tons	2.2	2.6-2.7	4.2-4.4	6.6-7.2

DEVELOPMENT PROGRAM

	1970	1980	2000	2020
Channel Depth (ft)	35(one way)	35 (2-way)	40 1/	-
Improvement Cost ($ millions)	-	15	25	-

1/ Alternative program - Consideration of offshore terminal to serve several ports. Cost not estimated.

TABLE K-26
SUMMARY - AREA 6

COMMERCIAL NAVIGATION

PROJECTED RANGE OF WATERBORNE COMMERCE

	1970	1980	2000	2020
Millions of Tons	32.2	39.6-51.7	65.2-84.4	102.6-127.2

INITIAL CAPITAL COSTS 1/

	1980	2000	2020
Millions of Dollars	65	145	-

1/ Costs shown are for channel deepening. The cost of the alternative program, an offshore terminal, for Portsmouth has not been estimated.

RECREATIONAL BOATING

PROJECTED PLEASURE CRAFT

	1970	1980	2000	2020
Registered Craft*	24,000	38,600	49,000	61,000
Total Craft	39,200	47,000	64,000	135,000

*Over 10 hp.

INITIAL CAPITAL COSTS
(millions of dollars)

	1980	2000	2020
Berths	3.8	2.9	3.0
Launching Facilities	0.3	0.6	2.4

The Corps of Engineers conducted surveys of recreational boating in Area 6 during the early-1960s. It was determined that 1,255 boats were permanently berthed on its coastal waters, and an additional 22,000 were occasional visitors.

Public facilities include about 60 launching facilities and 700 permanent slips or moorages. About 300 craft are available on a charter or rental basis.

Private capital can be counted on to accommodate increased boating as required. Public funds may be needed to assist local interests in the development of facilities, particularly in non-urban areas.

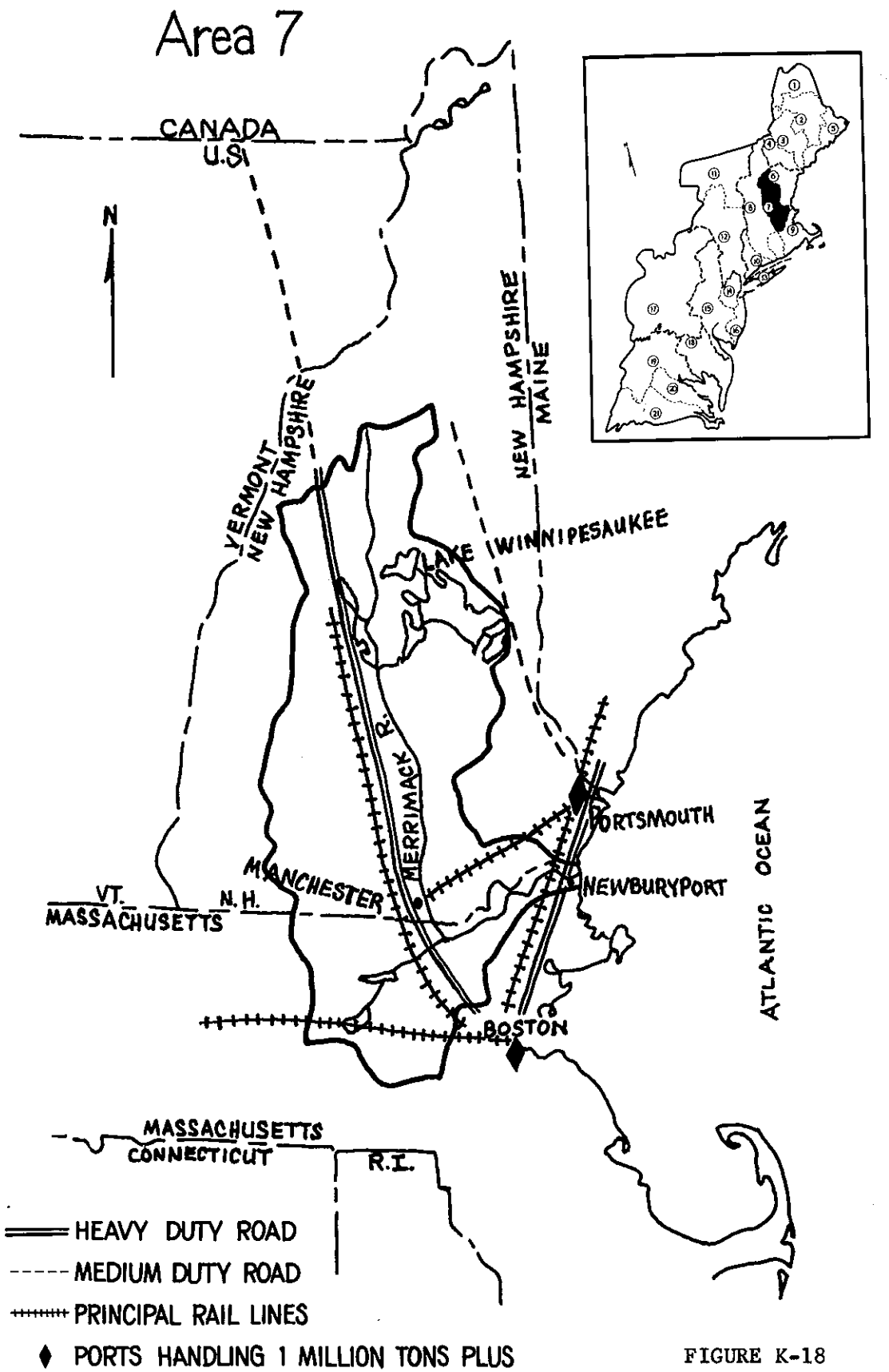

Area 7
CANADA
U.S.
N
VERMONT
NEW HAMPSHIRE
NEW HAMPSHIRE
MAINE
LAKE WINNIPESAUKEE
MERRIMACK R.
MANCHESTER
PORTSMOUTH
NEWBURYPORT
VT.
N.H.
MASSACHUSETTS
BOSTON
ATLANTIC OCEAN
MASSACHUSETTS
CONNECTICUT
R.I.
HEAVY DUTY ROAD
MEDIUM DUTY ROAD
PRINCIPAL RAIL LINES
PORTS HANDLING 1 MILLION TONS PLUS

FIGURE K-18

Commercial navigation is very small in Area 7 and significant growth is not anticipated. However, the lakes and rivers are important for recreational use because of the relative proximity of urban areas, including Boston. Growth of boating will accentuate needs for control of pollution and overcrowding.

Land Transportation

The map of Area 7 (Figure K-18) clearly shows the intense competition of land transportation with navigation. Navigation development has been restricted because the best lines of communication through Area 7 originate in Portsmouth or Boston, in Areas 6 and 9 respectively. As a result, the arrival of waterborne commerce destined for Area 7 tends to pass through Boston or Portsmouth.

Waterways

The Merrimack River is the only potential commercially navigable waterway in Area 7. At the mouth of the river, there is severe tidally-induced shoaling and both sides of the river are in marshland. The existing channel depth is 9 feet to Newburyport Harbor, about 3 miles upstream from the mouth of the river. The waterways experience a tide range of 5.1 feet.

The northern half of Area 7 has hundreds of lakes over 10 acres in size. Lake Winnipesaukee, the largest, covers about 70 square miles.

Service Factors

Production in Area 7 includes textiles, leather goods, chemicals, lumber, paper, machinery, metals, stone, sand and gravel. Most of the commodities are either consumed locally or in Boston, which is within 100 miles. The Area has a population of 1.2 million people.

COMMERCIAL NAVIGATION

Major Ports

Merrimack River. A small fishing fleet is based at Newburyport, on the Merrimack River, but reports indicate only a few tons (64 tons in 1970) of fish and shellfish each year. No other types of waterborne commerce are expected to be reported before 2020.

TABLE K-27
SUMMARY - AREA 7

COMMERCIAL NAVIGATION

No commercial development program appears likely.

RECREATIONAL BOATING

PROJECTED PLEASURE CRAFT

	1970	1980	2000	2020
Registered Craft*	23,000	39,000	50,000	59,000
Total Craft	50,000	67,000	93,000	165,000

*New Hampshire - over 10 hp.; Massachusetts - 5 or more hp.

INITIAL CAPITAL COSTS
(millions of dollars)

	1980	2000	2020
Berths	0.4	0.3	0.2
Launching Facilities	0.3	0.5	1.2

RECREATIONAL BOATING

Lake Winnipesaukee is important for recreational boating, not only because of its size and location adjacent to the White Mountain National Forest, but also because it lies within 60 miles of a resident population of almost 2 million people. Much of the lake's shoreline is privately owned and only partially developed, but there are about 31 public launching facilities.

Newburyport, on the Merrimack Estuary, has 15 marinas with over 500 permanent moorages and slips, as well as 13 launching facilities.

Private enterprise has the ability and probably the inclination to develop Area 7 to meet recreational boating needs. However, regulating the density of recreational craft on the water will have to remain as a government function. It seems likely that government will have to face the responsibility of guiding recreational boating development rather than trying to encourage it.

AREA 8. CONNECTICUT RIVER BASIN

The large population and industrial activity along the lower Connecticut River favor commercial navigation. Further development would require programs to reduce physical restrictions between Long Island Sound and Springfield, Mass., and to assure the availability of water for lockage. Overcrowding may be the biggest potential problem associated with recreational boating in this area.

Land Transportation

Land transportation development in Area 8 expedites movement throughout the Area (See Figure K-19), and competes with navigation because it provides good lines of communication into the Area from the major ports of Boston, New Haven and Albany. This competition is heightened by the fact that rail lines and highways closely parallel the Connecticut River.

Petroleum pipelines between New Haven, Hartford, Springfield and Providence probably represent the most severe competition to commercial navigation.

Waterways

The mainstem Connecticut River physically dominates Area 8, and is by far the most important to recreational and commercial navigation. The 52-mile stretch from Long Island Sound to Hartford, has been improved to provide a minimum width of 150 feet and a minimum depth of 15 feet. Enfield Dam and Enfield Rapids in the stretch between Hartford and Springfield are bypassed by the Windsor Locks Canal. The channel between Hartford and Springfield is poorly defined, between 1 and 7 feet deep and from 30 to 700 feet wide. Above Springfield, the river is navigable for short distances by vessels requiring less than 2 feet of depth.

Lakes provide the water surface for navigation in the northern half of the Area. There are several hundred lakes comprising over 30,000 acres. The large lake shown on the map above Springfield is Quabbin Reservoir, whose 20-square-mile area is not included in the above acreage figure because it is a public water supply source with stringent boating limitations.

The Connecticut is closed to navigation between November and April because of ice.

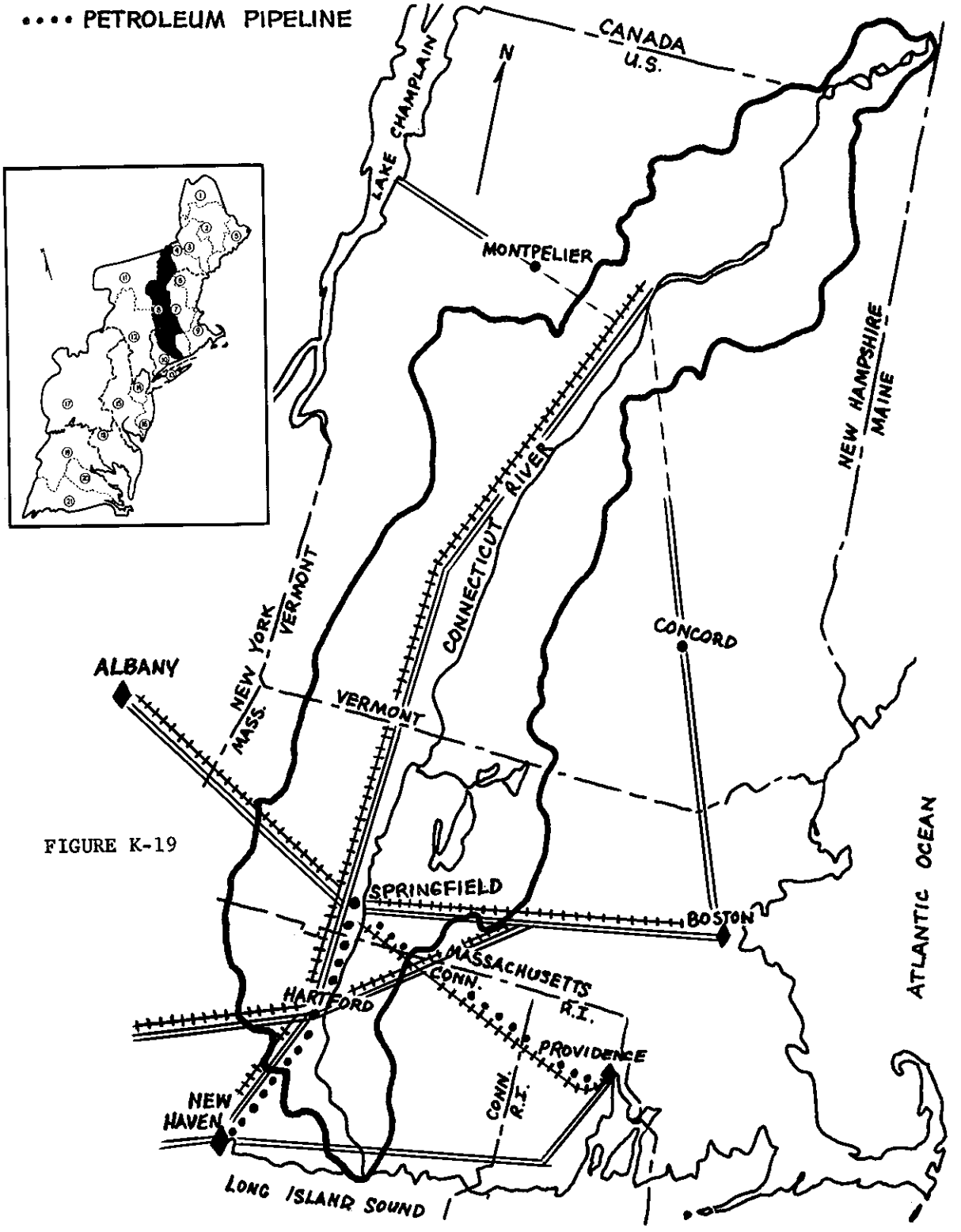

HEAVY DUTY ROAD
MEDIUM DUTY ROAD
PRINCIPAL RAIL LINES
PORTS HANDLING 1 MILLION TONS PLUS
PETROLEUM PIPELINE
Area 8
CANADA
U.S.
LAKE CHAMPLAIN
N
MONTPELIER
NEW HAMPSHIRE
MAINE
CONNECTICUT RIVER
NEW YORK
VERMONT
MASS.
VERMONT
CONCORD
ALBANY
SPRINGFIELD
BOSTON
MASSACHUSETTS
CONN.
R.I.
HARTFORD
PROVIDENCE
CONN.
R.I.
NEW HAVEN
LONG ISLAND SOUND
ATLANTIC OCEAN

FIGURE K-19

TABLE K-28
COMMODITY DISTRIBUTION - AREA 8

		1955		1965		1968	
Total - 1000's of tons		2,530	100%	3,100	100%	3,600	100%
Residual fuel oil	D/I	382	15%	632	20%	1,394	38%
Gasoline	D/I	836	33%	1,000	34%	1,000	28%
Distillate fuel oil	D/I	835	33%	866	28%	869	24%
Jet fuel/Kerosene	D/I	91	4%	214	7%	263	7%
Other petroleum	D/I	21	1%	78	2%	87	2%
Cement	D/I			23		27	
Coal	D/I	207	8%	230	7%		
Chemicals	D/I	115	5%				

D = Domestic, I = Import.

TABLE K-29
PORT SUMMARY - AREA 8 (CONNECTICUT RIVER)

PROJECTED WATERBORNE COMMERCE

	1970	1980	2000	2020
Millions of Tons	3.8	4.4-4.9	5.9-8.0	8.0-12.9

DEVELOPMENT PROGRAMS

	1970	1980	2000	2020
Mouth to Hartford				
Channel depth (ft)	15	16	18	20
Improvement Cost ($Million)	-	8	14	14

Service Factors

Industrial consumption and production in Area 8 tend to favor navigation development because of its diversity and quantity. There is heavy production of metal products, machinery, scrap metal and textiles, and large numbers of people are employed in the chemical, lumber and paper products industries. Each of these industries requires raw material suited for waterborne delivery, or produces a commodity amenable to waterborne shipment.

Commodity demand is generated by 1.6 million people, of whom over 87% live in the vicinity of the navigable portion of the Connecticut River, in the southern half of Area 8. The volume of demand generated by so many people residing in that relatively small area favors navigabion development.

COMMERCIAL NAVIGATION

Commodity Distribution

Table K-28 shows the relative importance, volume and trends of the waterborne commerce in Area 8 over the recent past.

Major Ports

Connecticut River. Since 1955, the number of self-propelled vessels using the Connecticut River has declined sharply, while barge traffic has increased correspondingly. Waterborne commerce increased by nearly 50% in the 14 years from 1955 to 1968, without overcrowding the waterway. Commercial traffic does not go beyond Hartford at present, nor is any significant traffic projected to 2020.

Waterborne commerce grew at a rate of 2.6% from 1949 to 1967. However, for the 10-year period ending in 1967, its growth rate was only 1.1%. Commerce averaged 3,146,000 tons for the three years prior to 1968, and the 1970 commerce was 3,815,000 tons. The prospective commerce has been projected at a low annual growth rate of 1.5% and a high rate of 2.5%.

RECREATIONAL BOATING

Along the Connecticut River below Hartford, there are 21 launching facilities and about 2,000 permanent slips or moorages. Because of the population density, there is a sizeable recreation demand that will increase significantly during the planning period. A study currently underway by the Corps of Engineers is investigating the feasibility of improving the waterway from Hartford to the Springfield area in the interest of recreational boating. A plan of improvement is being considered which would provide for dredging major shoals to establish a 6-foot deep and 100-foot wide channel; and a single large navigation lock at Windsor Locks to allow bypass of Enfield Dam. The plan if acceptable to local interests would result in a navigable waterway from Long Island Sound to Springfield, a distance of 85 miles. If constructed, little additional public funding will be required to support recreational development.

TABLE K-30
RECREATIONAL SUMMARY - AREA 8

RECREATIONAL CHANNEL IMPROVEMENTS

Hartford to Springfield	1970	1980	2000	2020
Channel depth (ft)	1-7 1/	6	-	-
Improvement Cost ($Millions)	-	9	-	-

1/ Although there is an authorized project for a 12-foot channel, it has never been constructed. Current investigations indicate that a 6-foot channel would be maximum feasible depth.

RECREATIONAL BOATING

PROJECTED PLEASURE CRAFT

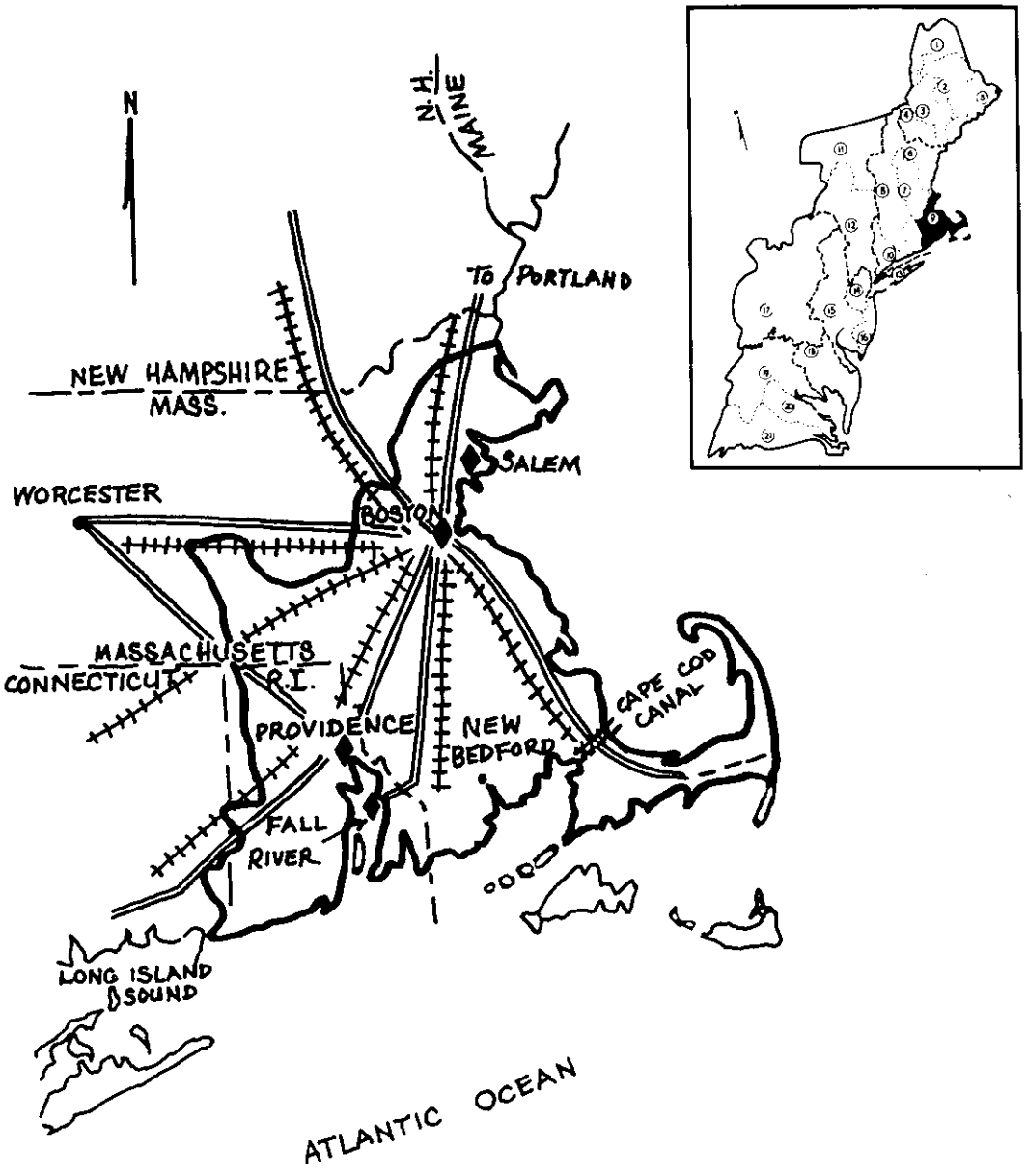
	1970	1980	2000	2020
Registered Craft*	38,000	41,000	50,000	66,400
Total Craft	71,000	96,500	171,000	298,000

*Massachusetts - 5 or more hp.; Connecticut & Vermont - all motor boats.

INITIAL CAPITAL COSTS
(millions of dollars)

	1980	2000	2020
Berths	--	0.2	0.4
Launching Facilities	0.5	1.5	2.5

Area 9



HEAVY DUTY ROAD

MEDIUM DUTY ROAD

PRINCIPAL RAIL LINES

♦ PORTS HANDLING 1 MILLION TONS PLUS

FIGURE K-20

AREA 9. SOUTHEASTERN NEW ENGLAND

Commercial navigation is a major activity in Area 9, particularly in the vicinity of Boston and Providence, and is expected to continue to grow. Above average growth is likely in the Boston area. Much of the recreational boating takes place in coastal areas such as Narragansett and Cape Cod Bays.

Land Transportation

The extensive land transportation development in Area 9 ranks it among those most complementary to navigation development in the entire North Atlantic Region. Only Philadelphia has a radial transportation system as direct to, or in a location as central to a comparable major population center, which, in the case of Area 9, is Boston. Land transportation development within 20 miles of Providence is almost as good (See Figure K-20).

Waterways

The highly irregular coastline of Area 9 has been very favorable to the development of ports and harbors. Providence, Boston, Fall River and Salem have authorized channel depths between 32 and 40 feet deep, and up to 1,200 feet in width. Ten other ports have access channels 15 to 24 feet deep and about 200 feet wide. The remaining ports have channels of from 8 to 10 feet deep and about 100 feet wide.

Cape Cod Canal, with a depth of 32 feet, is a short cut across Cape Cod, and ships using it eliminate more than 100 miles from the alternative route around the Cape.

There are hundreds of recreational harbors and lakes in Area 9, and its coastal waters are exceptionally well-protected for recreational boating by long spits, peninsulas and islands. Tide ranges 4.6 feet along the southern coast and 9 feet along the eastern coast.

Service Factors

Commodity demand is generated by 4.7 million people (1960). More than 97% of this population resides within 40 miles of the deep-draft ports of Boston and Providence. This population factor is very favorable to navigation development.

TABLE K-31
COMMODITY DISTRIBUTION - AREA 9

		1955		1965		1968	
Tonnage - in 1000's of tons		30,500	100%	33,900	100%	37,900	100%
Residual fuel oil	F/I	6,377	21%	7,781	23%	12,094	32%
Distillate fuel	D/I	6,864	22%	6,881	20%	10,555	28%
Gasoline	D/I	5,467	18%	9,103	27%	7,448	20%
Kerosene/Jet fuel	D/I	1,410	5%	1,055	3%	1,409	3%
Coal	D/I	3,549	12%	3,211	10%	1,298	3%
Scrap Metal	F/E	360	1%	494	1%	798	2%
Misc. petroleum	D/I	211		690	2%	778	2%
Sugar	F/I	468	2%	515	1%	443	1%
Cement	D/I	39		282		434	1%
Crude petroleum	D/I	2,458	8%	336	1%	345	1%
Chemicals	D/I	318	1%	124		201	
Lumber	F/I	124		290		190	
Iron	F/I	10		160		177	
Salt	F/I	5		113		173	
Limestone	F/I					135	
Fish	L	79		138		105	
Meat	F/I	6		120		80	

F = Foreign, D = Domestic, L = Local, I = Import, E = Export.

COMMERCIAL NAVIGATION

Commodity Distribution

Table K-31 shows the recent relative importance and volume and trends of the waterborne commerce in Area 9.

The coal indicated above is basically handled in equal amounts through Fall River and Salem.

Major Ports

Boston. The Port of Boston consists of an outer harbor formed and protected by islands and peninsulas, and an inner harbor formed by the confluence of several rivers. Its access channel is 1,200-1,500 feet wide, at depths ranging from 35 to 40 feet, and passes from the Atlantic Ocean through the outer harbor into the inner harbor as far as the mouths of each of the rivers. Thirty-five-foot channels extend into the rivers.

There are 156 piers, wharves, and docks, principally located along the rivers. Twenty-nine are designed for petroleum supported by storage (more than 2 million tons), 17 are for general cargo supported by open and covered storage areas (47 acres and 3 million square feet covered, 11 million cubic feet cold), 68 are for moorage and repairs, and several more are specialized for the handling and storage of liquified natural gas, cement, chemicals, salt, steel and seafood. Many of them have access to one of the two railroads serving Boston.

The main channel cannot be deepened beyond 43 feet, allowing 7 feet of cover, without relocating vehicular tunnels in the inner harbor. River channels can only be deepened with pier and bulkhead reconstruction, relocation of water supply tunnels and communication cables, removal of rock, and bridge reconstruction. There are about 28 lift or swing bridges distributed over the rivers. Many of these bridges restrict horizontal clearance to less than 80 feet.

Commerce increased at an annual rate of 0.6% for the 19 years through 1967, but experienced a higher average of 1.1% over the last 10 of those years. Commerce averaged 20,560,000 tons over the three years prior to 1968, and the 1970 tonnage was 26,870,000 tons. Projected commerce has a low annual growth rate of 1.1% and a high rate of 2.5%.

Providence. The Port of Providence has been developed along a 2.5-mile section of the Providence River about 10 miles from Narragansett Bay. Its 10-mile-long access channel is 40 feet deep and 600 feet wide.

Port facilities include 23 piers, wharves and docks. Ten are supported by open, covered and cold storage (60 acres, 150,000 square feet, 1.6 million cubic feet), and have access to the railroad. Thirteen were designed to receive or ship petroleum products, and are supported by a petroleum storage capacity of 1.2 million tons.

There are no major development restrictions in the main channel to Providence; however, just above Providence bridges restrict horizontal clearance to 50 feet and vertical clearance to 9 feet.

Commerce grew at an average annual rate of 1% for the 19 years through 1967, but had a higher average of 1.3% over the last 10 years of that period. Commerce averaged 9,120,000 tons for the three years prior to 1968 and the 1970 commerce was 9,870,000 tons. Projected commerce is expected to have an annual growth rate between 1.3% and 2.5%.

Fall River. Fall River is on the Northeast side of Narragansett Bay, about 18 miles from Providence, and has an existing access channel 35 feet deep and from 400 to 1,100 feet wide. Depths of 40 feet are authorized for the access channel to Tiverton and to the mouth of the Taunton River.

TABLE K-32
PORT SUMMARY - BOSTON

PROJECTED RANGE OF WATERBORNE COMMERCE

	1970	1980	2000	2020
Millions of Tons	26.9	30.0-34.3	37.3-56.3	46.4-92.3

DEVELOPMENT PROGRAMS

	1970	1980	2000	2020
Mystic River				
Channel Depth (ft)	35	-	43 1/	-
Improvement Cost ($Millions)	-	-	20	-
Main Ship Channel				
Channel Depth (ft)	35-40	-	43 1/	-
Improvement Cost ($Millions)	-	-	40	-
Weymouth-Fore and Town Rivers				
Channel Depth (ft)	35	-	40	45
Improvement Cost ($Millions)	-	-	20	25

1/ Alternative program - Off-loading terminal facility. Depth of 43 feet is maximum feasible depth due to limitation imposed by the Main Ship Channel tunnel. Estimated cost of off-loading facility has not been estimated.

TABLE K-33
PORT SUMMARY - PROVIDENCE

PROJECTED RANGE OF WATERBORNE COMMERCE

	1970	1980	2000	2020
Millions of Tons	9.9	11.4-12.8	14.7-21.0	19.1-34.4

DEVELOPMENT PROGRAM

	1970	1980	2000	2020
Channel depth (ft.)	40	-	45 1/	50 1/
Improvement Cost ($Millions)	-	-	25	30

1/ Alternative program - Consideration of offshore facilities, cost of which has not been estimated.

There are 15 harbor facilities in Fall River; nine in the principal harbor area on the Taunton River, and six in nearby Mount Hope Bay. Seven are used to receive and ship petroleum products and are supported by storage for 500,000 tons of petroleum products. The remainder are utilized for coal, moorage, or general cargo, and are supported by 113,000 square feet of covered storage and 3.4 acres of open storage. All of the facilities are served by rail and improved roads.

While there are 22 bridges in the vicinity of Fall River, only two pose potential restrictions to navigation development. Both cross the Taunton River and restrict horizontal clearance to 98 feet.

Commerce grew at an average annual rate of 4.8% for the 19 years through 1967 but had a much higher average growth of 6.2% over the last 10 years of that period. Commerce averaged 3,850,000 tons for the three years prior to 1963. Commerce in 1970 was 4,330,000 tons. The projected annual growth rates range from 2.3% to 3.5%.

Salem. Salem is located just north of Boston, and its 1.5-mile-long access channel is 32 feet deep and from 300 to 400 feet wide. Channels ranging in depth from 5 to 10 feet are maintained to various wharfs and yacht clubs in other areas of the port.

Port facilities include piers and wharfs specialized to handle coal and petroleum. There are no known restrictions to harbor development.

Waterborne commerce activity averaged an annual growth of 9.8% for the 19 years through 1967 but averaged only 1.4% over the last 10 years of that period. Commerce averaged 1,450,000 tons for the three years prior to 1968, and the 1970 commerce was 1,250,000 tons. The annual growth rate is expected to be between 1.4% and 2.5%.

New Bedford. The cities of New Bedford and Fairhaven form a port in the mouth of the Achshnet River. Its 5-mile-long access channel is 30 feet deep and 350 feet wide. Two of the 19 port facilities are designed to receive and ship petroleum products.

Deep-draft harbor development may be limited by a hurricane barrier seaward of the harbor, which limits the horizontal clearance to 150 feet and the depth to 35 feet.

Waterborne commerce averaged a 0.5% annual decline during the 19 years through 1967, but averaged an8.9% annual growth over the last 10 years of that period. Commerce averaged 450,000 tons for the 3 years prior to 1968. The 1970 commerce was 615,000 tons. The annual growth rates range from 2.3% to 3.5%.

TABLE K-34
PORT SUMMARY - FALL RIVER

PROJECTED RANGE OF WATERBORNE COMMERCE

	1970	1980	2000	2020
Millions of Tons	4.3	5.4-6.1	8.5-12.1	13.4-24.0

DEVELOPMENT PROGRAM

	1970	1980	2000	2020
Channel Depth (ft)	35 1/	40	45 2/	50
Improvement Cost ($Millions)	-	20	25	30

1/ A 40-foot depth is authorized for access channel to Tiverton and to the mouth of the Taunton River.

2/ Alternative program - Consideration of offshore terminal, cost of which has not been estimated.

TABLE K-35
PORT SUMMARY - SALEM

PROJECTED RANGE OF WATERBORNE COMMERCE

	1970	1980	2000	2020
Millions of Tons	1.25	1.5-1.7	2.0-2.7	2.6-4.5

DEVELOPMENT PROGRAMS

	1970	1980	2000	2020
Channel depth (ft)	32	-	35	-
Improvement Cost ($Millions)	-	-	5	-

TABLE K-36
PORT SUMMARY - NEW BEDFORD

PROJECTED RANGE OF WATERBORNE COMMERCE

	1970	1980	2000	2020
Millions of Tons	0.6	0.7-0.4	1.2-1.7	1.9-3.4

DEVELOPMENT PROGRAM

	1970	1980	2000	2020
Channel Depth (ft.)	30	-	-	35
Improvement Cost ($Millions)	-	-	-	4

Others. Boston, Providence, Fall River, Salem and New Bedford account for more than 95% of the waterborne commerce in Area 9. Nine other ports account for an additional 20,000 to 300,000 tons each, but are not discussed because of their small volume, which cannot be projected reliably. No development programs are foreseen in these other ports.

RECREATIONAL BOATING

There are scores of small lakes in Area 9. However, the great expanse of well-protected coastal waters, focuses attention on coastal boating. In Narragansett Bay and along the Southern shore of Area 9, there are more than 10,000 permanent berths or slips and about 115 launching facilities, including travelifts, or launching ramps, ranging from 12 to 250 feet wide. Along the Area's eastern coast, including Cape Cod Bay, there are approximately 5,900 permanent slips or moorages, and 82 launching facilities.

Development costs can be expected to be borne by private enterprise.

TABLE K-37
SUMMARY - AREA 9

COMMERCIAL NAVIGATION

PROJECTED RANGE OF WATERBORNE COMMERCE 1/

	1970	1980	2000	2020
Millions of Tons	42.9	49.0-55.8	63.7-93.8	83.4-158.6

INITIAL CAPITAL COSTS 2/

	1980	2000	2020
Millions of Dollars	20	135	89

1/ Commerce shown is for major ports discussed in the text.
2/ Costs shown are for channel improvements. Cost of the alternative program, of off-loading facilities for Boston, Providence, and Fall River, has not been estimated.

RECREATIONAL BOATING

PROJECTED PLEASURE CRAFT

	1970	1980	2000	2020
Registered Craft*	92,500	103,000	127,000	156,000
Total Craft	187,000	248,000	561,000	910,000

* Massachusetts - 5 or more hp.; Rhode Island - all motor boats.

INITIAL CAPITAL COSTS
(millions of dollars)

	1980	2000	2020
Berths	3.0	6.2	7.5
Launching Facilities	1.2	6.3	7.0

Commercial navigation is moderate at the several ports in this Area. High nearby population density as a positive service factor is counteracted by competition from other common carriers and other ports. Recreational boating is very high, particularly along the Connecticut Shoreline of Long Island Sound. Problems due to pollution, overcrowding and shore access may be anticipated.

Land Transportation

As shown on the map (Figure K-21), land transportation is very well developed along the coast, but does not expedite movement inland to a great degree. Land transportation is complementary to navigation development around New Haven, but tends to compete with navigation along the rest of the coast. Most of the modern, high-speed highways are toll roads, which may tend to reduce their competitiveness.

Waterways

Area 10 comprises almost half the shoreline of Long Island Sound. The Sound is exceptionally suited to navigation, due to its great natural depths ranging to over 100 feet. It provides safe passage for vessels of 40-foot draft in the southern half. Thirty-foot depths are available to within a mile of the Sound's North Shore.

Bridgeport and New Haven have channels of a 35-foot depth. New London has a channel depth of 33 feet. Other active waterways have depths averaging about 19 feet. The tide ranges about 7 feet.

Service Factors

Commodity demand is generated by 2.2 million people (1960), more than 80% of whom live within 20 miles of one of the seven most active ports. The population density definitely tends to support navigation, and would support it even more if there were fewer competing ports.

COMMERCIAL NAVIGATION

Commodity Distribution

Table K-38 shows the relative importance, volume, and trends of the waterborne commerce in Area 10.

Major Ports

New Haven. The access channel at New Haven is 35 feet deep and protected by breakwaters. Of the 40 port facilities, eight are

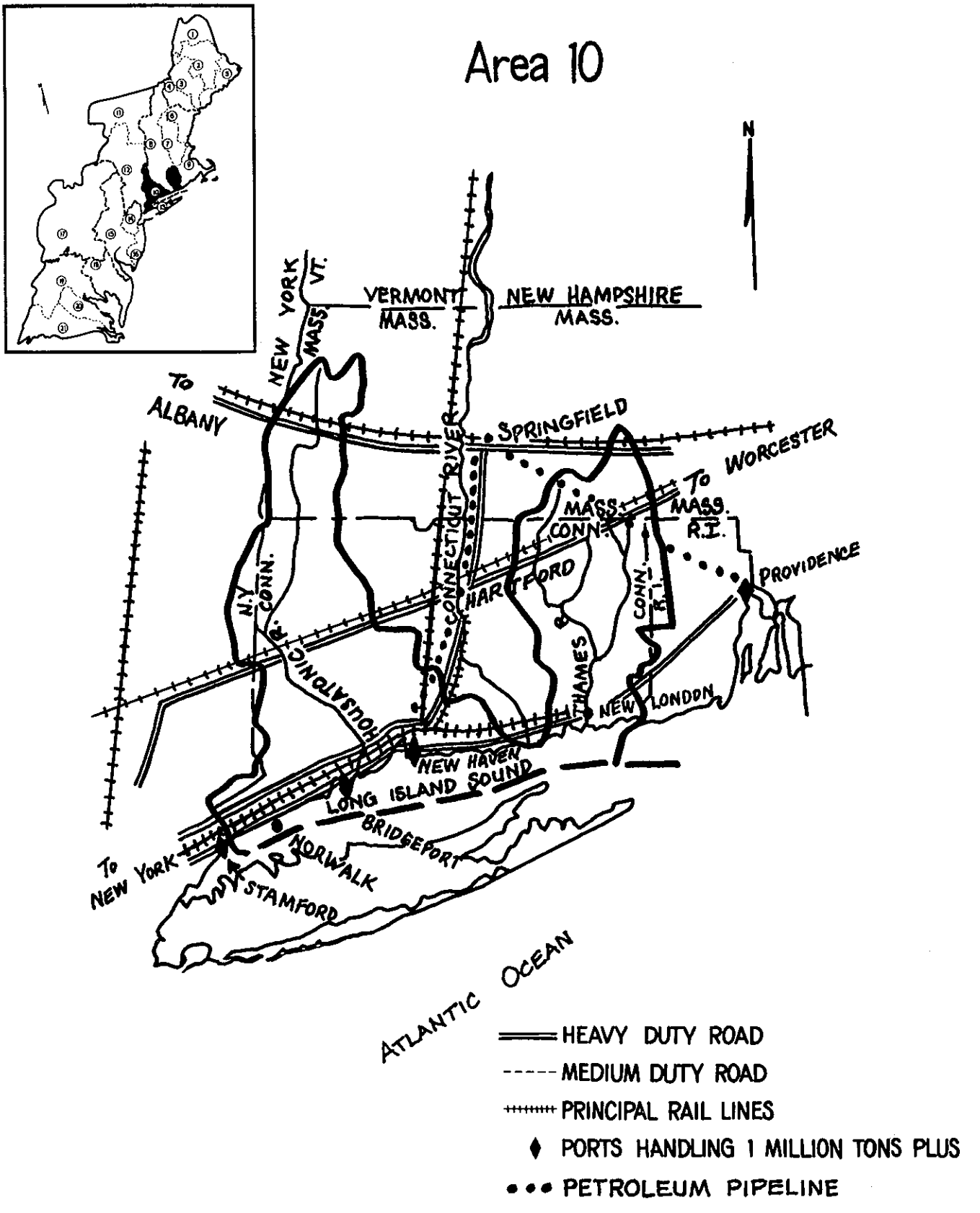

Area 10
N
VERMONT
MASS.
NEW HAMPSHIRE
MASS.
NEW YORK
VT.
MASS
To
ALBANY
SPRINGFIELD
To WORCESTER
CONNECTICUT RIVER
MASS.
CONN.
MASS.
R.I.
HARTFORD
PROVIDENCE
N.Y.
CONN.
HOUSATONIC R.
THAMES
CONN.
R.I.
NEW LONDON
NEW HAVEN
LONG ISLAND SOUND
BRIDGEPORT
NORWALK
To
NEW YORK
STAMFORD
ATLANTIC OCEAN
HEAVY DUTY ROAD
MEDIUM DUTY ROAD
PRINCIPAL RAIL LINES
PORTS HANDLING 1 MILLION TONS PLUS
PETROLEUM PIPELINE

FIGURE K-21

TABLE K-38
COMMODITY DISTRIBUTION - AREA 10

		1955		1965		1968	
Tonnage - 1000's of tons		13,900	100%	16,800	100%	20,000	100%
Residual fuel oil	F/I	3,361	24%	3,941	23%	6,177	31%
Distillate fuel oil	F/I	3,478	25%	4,875	29%	5,656	28%
Gasoline	D/I	1,911	14%	2,948	17%	2,373	14%
Coal	D/I	3,162	22%	2,703	16%	2,540	13%
Kerosene/jet fuel	D/I	529	4%	483	3%	470	2%
Sand and gravel	D/I	511	4%	390	2%	496	2%
Chemicals	D/I	167	1%	264	1%	418	2%
Scrap Iron	F/E	257	2%	270	1%	330	3%
Iron	F/I	200	1%	238	1%	225	1%
Misc. Petroleum	D/I			178	1%	110	
Salt	F/I			29		119	
Cement	F/I	16		141	1%	139	
Stone	F/I	12		48		140	
Molasses	F/I	55		74		59	

F = Foreign, D = Domestic, I = Import, E = Export.

TABLE K-39
PORT SUMMARY - NEW HAVEN

PROJECTED RANGE OF WATERBORNE COMMERCE

	1970	1980	2000	2020
Millions of Tons	11.6	14.6-16.4	23.0-32.6	36.2-64.8

DEVELOPMENT PROGRAM

	1970	1980	2000	2020
Channel Depth (ft)	35	40	45 1/	50
Improvement Cost ($Millions)	-	36	50	60

1/ Alternative program - Consideration of offshore terminal, cost of which has not been estimated.

served by the main channel and five are specialized to receive and ship petroleum products and are supported by petroleum storage (1 million tons). The remaining facilities have special equipment to handle general cargo, salt, chemicals, cement, or fish and are supported by open, covered and cold storage (15.7 acres, 150,000 square feet, 400,000 cubic feet, respectively). Most of the facilities have access to rail lines and improved roads.

Waterborne commerce increased at an average annual rate of 3.6% for the 19 years through 1967, but had a much higher raise of 4.8% over the last 10 years of that period. Commerce averaged 10,300,000 tons for the three years prior to 1968. The 1970 commerce was 11,600,000 tons. The prospective annual growth rate ranges from 2.3% to 3.5%.

Bridgeport. The Bridgeport access channel is 35 feet deep, with branch channels having depths of 7 to 30 feet. There are 29 port facilities. Most of the supporting petroleum storage (300,000 tons) is located adjacent to the service channels as are the covered and cold storage (170,000 square feet and 147,000 cubic feet, respectively).

Further development may result in extensive bridge, cable and pipeline relocations.

Waterborne commerce grew at an average annual rate of 1.5% during the 19-year period ending in 1967, but had a much higher growth average of 2.6% during the last 10 years of that period. Commerce averaged almost 2,700,000 tons for the three years prior to 1968. The 1970 commerce was 3,800,000 tons. The projected annual growth rates range from 1.5% to 2.6%.

Housatonic River. The Housatonic River is navigable 14 miles upstream from Long Island Sound, but most waterborne commerce is handled within the first 5 miles where the channel is maintained at the authorized depth of 18 feet. Above the 5-mile point, the channel is maintained at 7 feet. Several bridges crossing the river may have to be modified if the waterway is improved.

Waterborne commerce grew at an annual average rate of 4.3% during the 19-year period ending in 1967, but averaged only 2.0% in the last 10 of those years. Commerce averaged 1,040,000 tons for the three years prior to 1968. The 1970 tonnage was 760,000 tons. The declining traffic, poor harbor conditions and proximity of better ports led to the conclusion that no development program should be considered for the Housatonic River. Projected waterborne commerce is shown in Table K-41.

Norwalk. Norwalk is 11 miles south of Bridgeport on Long Island Sound. Its access channel is 10 feet deep (12 feet at the mouth). Waterway improvement may require the modification of three bridges which restrict horizontal clearance to 58 feet.

TABLE K-40
PORT SUMMARY - BRIDGEPORT

PROJECTED RANGE OF WATERBORNE COMMERCE

	1970	1980	2000	2020
Millions of Tons	3.8	4.4-4.9	5.9-8.2	8.0-13.7

DEVELOPMENT PROGRAM

	1970	1980	2000	2020
Channel Depth (ft)	35	35(widening)	-	40 1/
Improvement Cost ($Millions)	-	10	-	35

1/ Alternative program - Consideration of offshore terminal, cost of which has not been estimated.

TABLE K-41
PORT SUMMARY - HOUSATONIC RIVER, NORWALK AND STAMFORD

PROJECTED RANGE OF WATERBORNE COMMERCE
(Millions of tons)

	1970	1980	2000	2020
Housatonic River	0.8	0.9-1.1	1.3-1.7	1.7-2.8
Norwalk	1.1	1.4-1.6	2.2-3.1	3.4-6.1
Stamford	1.0	1.3-1.4	2.0-2.8	3.1-5.6

DEVELOPMENT PROGRAMS

No commercial development program appears likely in any of the three areas.

Waterborne commerce increased at an annual average rate of 9% during the 19-year period ending in 1967, but the average spurted to 14% in the last 10 of those years. Commerce averaged 1,260,000 tons for the 3 years prior to 1968. The 1970 commerce was 1,100,000 tons, nearly 80% coal. Although commerce is projected to increase at an annual rate between 2.3% and 3.5% (Table K-41), the present channels are considered to be adequate during the planning period. Therefore, no development plan is suggested for Norwalk.

TABLE K-42
PORT SUMMARY - THAMES RIVER

PROJECTED WATERBORNE COMMERCE

	1970	1980	2000	2020
Millions of tons	2.0	2.2-3.5	3.1-4.2	4.8-5.5

DEVELOPMENT PROGRAMS

	1970	1980	2000	2020
New London Harbor				
Project Depths (ft)	33	40	-	45
Improvement Cost($Millions)	-	12	-	20
Thames River to Norwich				
Project Depths (ft)	25	-	-	Not Estimated
Improvement Cost ($Millions)	-	-	-	-

Stamford. Stamford is 40 miles from New York and 10 miles from Norwalk in the mouth of the Rippowam River. Its access channel is 15 feet deep (18 feet deep at the mouth). A hurricane barrier may interfere with deep-draft harbor development, but the natural river channel width is the major constraint.

Waterborne commerce grew at an annual average rate of 2.3% during the 19-year period ending in 1967, and 3% over the last 19 years of the period. Commerce averaged 950,000 tons for the three years prior to 1968. The 1970 commerce was 1,020,000 tons, including petroleum, sand and gravel. Although commerce is projected to increase at an annual rate between 2.3% and 3.5% (Table K-41), the present channels are considered adequate during the planning period. Therefore, no development plan is suggested for Stamford.

Thames River. The Thames River is located midway between Narragansett Bay and New Haven. Its access channel is 33 feet deep for the three miles to New London, and 25 feet deep for the next 12 miles to Norwich.

There are 36 port facilities at New London. Eight are designed for petroleum and are supported by storage (175,000 tons), and the remainder are for marine products, moorage, repairs, or general cargo supported by covered storage (150,000 square feet). Norwich has specialized facilities for coal and petroleum supported by storage (1 million tons and 500,000 tons, respectively). Both ports are served by rail lines and improved roads. Two bridges may inhibit waterway improvements because they restrict horizontal clearance to 150 feet immediately above New London.

Waterborne commerce grew at an average annual rate of 2.7% during the 19-year period ending in 1967, but experienced an average annual decline of about 1% over the last 10 of that period. Commerce averaged 1,820,000 tons for the three years prior to 1968. The 1968 commerce was 1,430,000 tons. In 1969, the commerce jumped to over 3 million tons, with over 1 million deep-draft. The deep-draft commerce is projected to be 1.2 to 1.5 million tons in 1980 and 2.5 to 3.5 million tons by 2020.

The development programs shown in Table K-42 reflect the assumed decline of Norwich's coal commerce. This decline is expected to be more than offset by the increase of petroleum products to New London, where an oil burning power plant will be constructed in the 1970s. Development programs to Norwich are not considered feasible to the year 2000. A program after 2000 may be feasible, but no attempt has been made in this report to estimate its magnitude or cost.

RECREATIONAL BOATING

Long Island Sound is well suited for recreational boating and the population density is very high along the Connecticut shoreline. There are more than 10,000 permanent slips or moorages and about 100 launching facilities in Area 10.

Private enterprise can be expected to furnish most of the capital required for new facilities because of the expected high-density use, but overcrowding may have to be controlled by public agencies and assistance provided to private enterprise in securing locations for recreational boating facilities along the coast.

TABLE K-43
SUMMARY - AREA 10

COMMERCIAL NAVIGATION

PROJECTED RANGE OF WATERBORNE COMMERCE

	1970	1980	2000	2020
Millions of Tons	20.3	24.5-29.4	37.5-52.6	57.2-98.5

INITIAL CAPITAL COSTS 1/

	1980	2000	2020
Millions of Dollars	58	50	115

1/ Costs shown are for channel improvements. Costs of the alternative programs, offshore terminals for New Haven and Bridgeport, have not been estimated.

RECREATIONAL BOATING

PROJECTED PLEASURE CRAFT

	1970	1980	2000	2020
Registered Craft*	72,000	78,000	103,000	125,000
Total Craft	125,000	167,000	308,000	665,000

*All motor boats.

INITIAL CAPITAL COSTS
(millions of dollars)

	1980	2000	2020
Berths	0.5	6.5	5.7
Launching Facilities	0.8	2.8	7.0

TABLE K-44
SUMMARY - SUB-REGION B

COMMERCIAL NAVIGATION

PROJECTED RANGE OF WATERBORNE COMMERCE - MAJOR PORTS

	1970	1980	2000	2020
Millions of tons	98.2	117.5-141.8	172.3-238.8	251.2-397.2

INITIAL CAPITAL COSTS 1/

	1980	2000	2020
Millions of Dollars	151	344	218

1/ Costs shown are for channel improvements. Costs of Alternative programs, offshore terminals in Areas 6, 9 and 10, have not been estimated.

RECREATIONAL BOATING

PROJECTED PLEASURE CRAFT

	1970	1980	2000	2020
Registered Craft*	249,600	299,600	379,000	467,400
Total Craft	472,000	625,500	1,197,000	2,173,000

*Maine & New Hampshire - over 10 hp.; Massachusetts - over 5 hp.; Rhode Island, Vermont & Connecticut - all motorboats.

INITIAL CAPITAL COSTS
(millions of dollars)

	1980	2000	2020
Berths	7.7	16.1	16.8
Launching Facilities	3.1	11.7	19.9
Channel Improvements	9.0	--	--

SUB-RECION C

Sub-region C ranks third among the Sub-regions in commercial navigation activity, but is almost equal to Sub-region B. Recreational boating is a very important activity and is expected to grow significantly throughout the planning period.

COMMERCIAL NAVIGATION

Areas 12 and 13 are significantly developed for commercial navigation and most future effort will consist of modernization of existing facilities with a moderate amount of channel improvement. Area 11 offers significantly less potential for commercial navigation.

RECREATIONAL BOATING

Each of the Areas of Sub-region C have excellent access to recreational boating water. Area 11's assets are primarily fresh water lakes. Area 12's include fresh water rivers, canals, and a tidal river. Area 13 is adjacent to Long Island Sound and has extensive barrier beaches fronting the Atlantic Ocean which protect large salt water bays. The boating opportunities in the Sub-region tend to be more important as one progresses south because of the increasing population density in that direction.

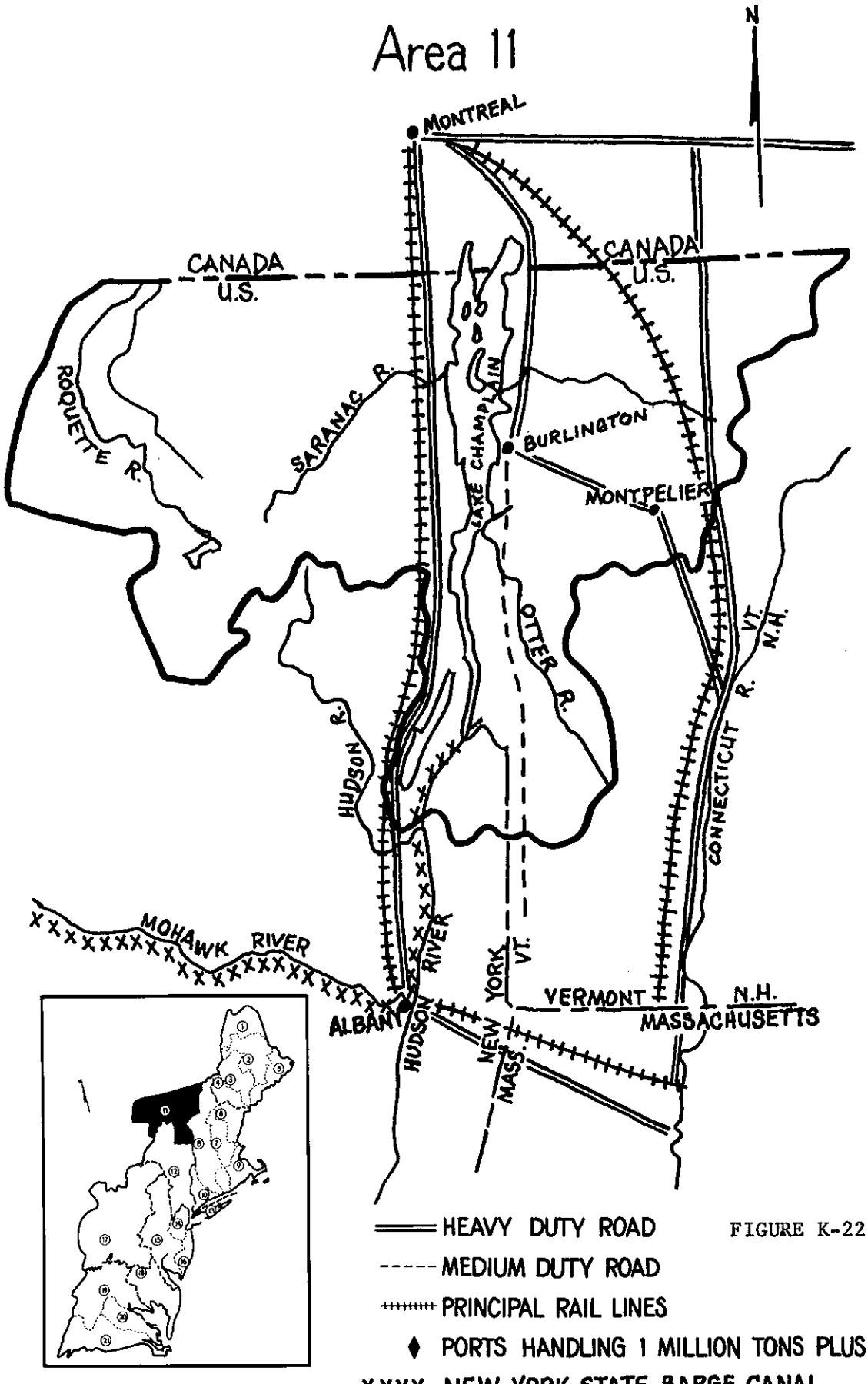

Area 11
N
MONTREAL
CANADA
U.S.
CANADA
U.S.
ROQUETTE R.
SARANAC R.
LAKE CHAMPLAIN
BURLINGTON
MONTPELIER
OTTER R.
VT.
N.H.
CONNECTICUT R.
HUDSON R.
MOHAWK RIVER
HUDSON RIVER
ALBANY
NEW YORK
VT.
VERMONT
N.H.
MASSACHUSETTS
MASS.
HEAVY DUTY ROAD
MEDIUM DUTY ROAD
PRINCIPAL RAIL LINES
PORTS HANDLING 1 MILLION TONS PLUS
XXXX NEW YORK STATE BARGE CANAL

FIGURE K-22

AREA 11. LAKE CHAMPLAIN AND ST. LAWRENCE DRAINAGE

Commercial navigation activity is small and is not expected to increase significantly. Recreational boating is an important means of satisfying recreational demands. This activity is moderate at present and should keep pace with the growth of the Area. The remote location of Area 11 will be a moderating influence on all trends.

Land Transportation

The land transportation system competes heavily with navigation as shown on the map of Area 11 (Figure K-22). Both Montreal and Albany are major ports with excellent access to Area 11.

Waterways

Lake Champlain splits Area 11, and is more than 100 miles long, up to 12 miles wide, and generally deeper than 100 feet. The lake drains into the St. Lawrence River at its northern end and the southern end is connected to the Hudson River by the Champlain Canal. Both ends have been developed for navigation by canals and locks. The canals generally allow for two-way traffic in the 12-foot channel, except for short distances in some land and rock cuts. Weather is the greatest drawback to navigation development, because cold weather and ice can close the waterway up to six months each year. Development of this Area must compare with development in Area 12, which controls the U. S. access to Area 11.

There are many lakes in the western half of the Area suitable for recreational boating.

Service Factors

The industrial production of Area 11 includes several million tons each year of rock, sand and gravel, which are presently moved by other common carriers to the south. Production also includes machinery, lumber and ores. It is unlikely that ore movements will be significant under any development because the mines are located closer to the St. Lawrence River than to Lake Champlain. Except for petroleum, industrial demand has not been satisfied by navigation.

Commodity demand is generated by about 500,000 people, who are spread relatively uniformly throughout the Area. There are only two population concentrations of over 10,000 adjacent to the Lake.

COMMERCIAL NAVIGATION

Commodity Distribution

The only reported commercial commerce in recent years has been petroleum products originating from the south.

Major Ports

Lake Champlain. On Lake Champlain, Plattsburg is the major port on the western shore although Rouses Point, Chazy Landing, Port Henry and Port Kent have reported activity in the past. Burlington is the major port on the Eastern Shore. Shelburne Bay, a few miles south, is extensively developed for recreational boating. Burlington and Plattsburg just about split the commerce passing through the narrows.

Commerce increased at an average rate of nearly 10% over the 19 years ending in 1967, but during the last 10 years of that period the growth rate averaged only 1.4%. Commerce averaged 1,260,000 tons for the three years prior to 1968. The 1970 commerce was 1,180,000 tons.

TABLE K-45
PORT SUMMARY - AREA 11

PROJECTED RANGE OF WATERBORNE COMMERCE

	1970	1980	2000	2020
Millions of Tons	1.2	1.3 - 1.6	1.4 - 2.4	1.6 - 3.9

DEVELOPMENT PROGRAMS

No commercial development plan is considered likely.

No major development program is expected to be required in Lake Champlain during the planning period. To accommodate and induce a major increase in commercial traffic in the Area, improvements will also be required in the portion of the barge canal connecting the Hudson River below Troy Lock and Lake Champlain. These improvements are very costly due, in large part, to the high cost of lock improvements. In addition, attempts to make major improvements to the canal are likely to meet with local opposition. The justification for major improvements is further clouded by the possibility of petroleum pipelines successfully competing with water transportation, the uncertainty in demand of the Air Force base at Plattsburg, and consideration of the unfavorable weather conditions.

RECREATIONAL BOATING

The size and central location of Lake Champlain tends to draw attention from the scores of other lakes in Area 11. The Lake has been somewhat developed for recreational boating. There are 57 facilities, which include more than 500 permanent slips or moorages and 100 launching facilities. Much of the boating that occurs in Area 11 is expected to satisfy some of the need in other Areas and also in Canada. Public funds may be required to satisfy much of the demand for facilities. In addition to the capital costs shown in Table K-46 for berths and launching facilities, future lock improvements may be required to accommodate recreational vessels entering and leaving the Area. Since lock capacity is shared between commercial and recreational traffic, and the uncertainty as to the lockages required for commercial vessels, canal improvements have not been included in the recreational development program. However, future studies should be conducted to determine the need for and the feasibility of such improvements.

TABLE K-46
RECREATIONAL SUMMARY - AREA 11

RECREATIONAL BOATING

PROJECTED PLEASURE CRAFT

	1970	1980	2000	2020
Registered Craft*	23,000	25,000	28,700	33,600
Total Craft	23,000	28,800	44,500	66,000

*All motor boats

INITIAL CAPITAL COSTS
(millions of dollars)

	1970	1980	2000	2020
Berths	--	--	0.1	0.1
Launching Facilities	--	0.4	1.3	1.4
Canal Improvements	Not determined			

Area 12

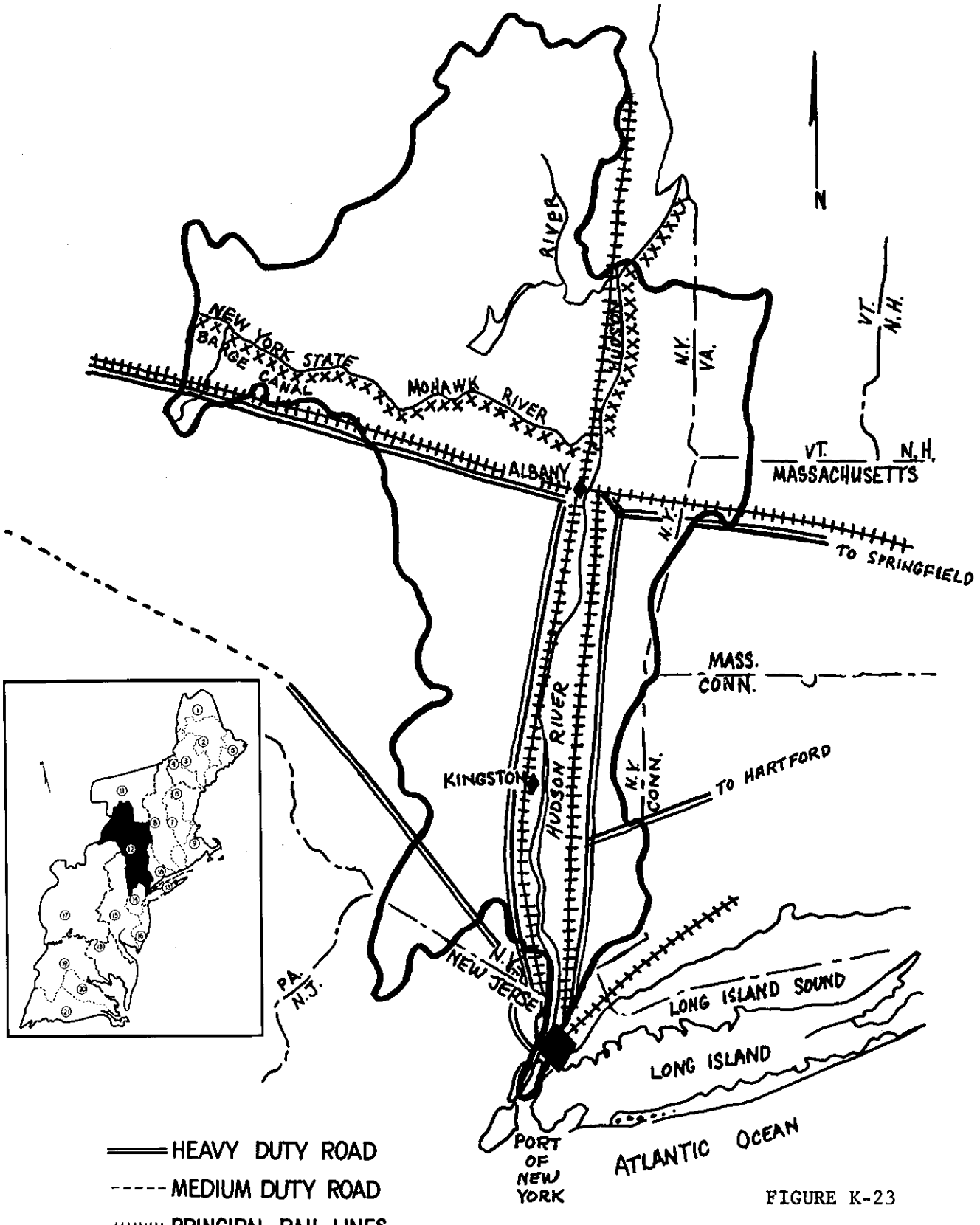


FIGURE K-23

AREA 12. HUDSON RIVER BASIN

Area 12 ranks among the top eight of the Areas of the Region in commercial navigation activity, but its standing may decline somewhat by the end of the planning period because of physical constraints and water quality conflicts. Recreational boating is important, although moderate, in Area 12.

Land Transportation

The highways and railroads shown on the map of Area 12 (Figure K-23), compete heavily with navigation because of their parallel development along the commercial waterways. The major exception to this is the land transportation system around Albany, which has high-speed, heavy-duty roads and rails radiating from it in all directions.

Waterways

Commercially navigable water in Area 12 is interconnected but varies widely in available depths. The canals in Area 12 extending north from the Albany area are 12 feet deep, 75 to 200 feet wide, and the Federally-improved canals going west from Albany are 14 feet deep and 200 feet wide. The Canal System provides access to Area 11, western New York State, and the Great Lakes region outside the boundaries of the NAR Study. Its greatest drawbacks are that the System is closed to traffic for several months of the year because of ice and flood conditions, and the length of time required by vessels to move from one end to the other because of lockages.

The Hudson River portion of Area 12 extends from New York City (George Washington Bridge) to Troy Lock, near Albany, with a minimum depth of 32 feet and widths ranging from 400 to 600 feet. It provides access to Areas 13 and 14, as well as all Areas accessible from the Atlantic Ocean and the Canal System. Ice closes the upper portion of the Hudson for several months each year, but the channel can be opened to traffic to Albany with ice breakers.

Service Factors

The production of Area 12 tends to support navigation. There is a large production of food, textiles, paper, metals, machinery and instruments, most of which are amenable to waterborne transportation, but are presently being shipped by other means. Cement, stone, sand and gravel are produced abundantly throughout the Area and are partially moved by water to the New York City area.

The demand for goods is concentrated in the cities, a fact favorable to navigation because most of the 2 million people of the Area live along the navigable waterways. However, the population centers are widely spread, tending to reduce their potential for handling bulk commodities.

The major consumed commodities are petroleum products, which strongly supports navigation along the Hudson River because of the volumes being transported.

COMMERCIAL NAVIGATION

Commodity Distribution

Table K-47 shows the distribution of reported waterborne commerce along the Hudson River. Fuel and construction materials account for more than 90% of the total commerce.

TABLE K-47
COMMODITY DISTRIBUTION - AREA 12

		1955		1965		1968	
Total - in 1000's of tons		20,200	100%	21,563	100%	23,255	100%
Rock, Sand & Gravel	D/E	1,830	9%	5,840	27%	7,400	32%
Distillate Fuel Oil	D/I	3,840	18%	4,090	19%	4,780	20%
Gasoline	D/I	3,200	15%	4,150	19%	3,700	16%
Cement	D/E			1,790	8%	2,900	12%
Residual Fuel Oil	D/I	1,400	7%	2,540	12%	2,200	9%
Sugar/Molasses	F/I	420	2%	510	2%	1,014	5%
Jet Fuel/Kerosene	D/I	642	3%	680	3%	570	3%
Asphalt	D/I			343	2%	407	2%
Grain	F/E	1,200	6%	217	1%	300	1%

D = Domestic, F = Foreign, I = Import, E = Export

Major Ports

Hudson River. The Hudson River from New York City to Albany is 150 miles long, with a 32-foot depth for widths of at least 400 feet. Nine bridges cross the river and generally allow 500 to 1,000 feet of horizontal clearance, and 135 feet vertical clearance at mean low water. Dozens of pipelines and submarine cables cross the river, most at depths of 39 feet or greater. There are several ports along the river, but Albany is the most developed and handles more than one-third of the reported commerce. Its facilities are basically designed to handle petroleum products, general cargo, and grains.

The number of reported vessel trips has dropped sharply since 1955. Vessel size is increasing.

Commerce grew at an average annual rate of 3.2% for the 19 years ending in 1967, and at 3% during the last 10 of those years. Commerce averaged 20,000,000 tons for the three years prior to 1960. The 1970 commerce was 26,600,000 tons.

TABLE K-48
PORT SUMMARY - HUDSON RIVER

PROJECTED RANGE OF WATERBORNE COMMERCE

	1970	1980	2000	2020
Millions of Tons	26.6	31.2 - 33.5	49.0- 55.0	77.0-90.2

DEVELOPMENT PROGRAM

	1970	1980	2000	2020
Channel Depth (ft)	32	-	45 to Kingston	1/
Improvement Cost ($ millions)	-	-	80	27

1/ Petroleum pipelines from Kingston to Albany.

Canal System. The Canal System begins upstream of Troy Lock and includes 512 miles of component canals that are controlled by 57 locks. The waterway is generally 200 feet wide and 12-14 feet deep, and is crossed by some 300 bridges, which restrict vertical clearance to 20 feet in the Federal sections, and to between 20 feet and 15 feet elsewhere. There are also 225 cables which present similar restrictions. The locks are generally 310 feet long, 45 feet wide, and 12-13 feet deep. The system is generally closed from December to April. There are numerous recreational facilities along the system. Railroad access is available at many of the canal-side cities.

Waterborne commerce generally moves north and west, and declined at an annual rate of 1.9% through the 19 years ending in 1967, but this annual decline accelerated in the last 10 of those years to 2.2%. Commerce averaged 3,210,000 tons for the three years prior to 1968. The 1970 commerce was 2,735,000 tons. The Canal System distributes this commerce through its component canals. Through-traffic accounts for 55% of the reported tonnage. Nearly half of the total tonnage travels the Champlain Canal into Area 11. The types of cargos have remained generally the same, with petroleum the dominant commodity. Commercial navigation is not likely

to increase greatly without canal improvements due in part to capacity limitations, competition from other modes of transportation, canal closures, and delivery time limitations.

TABLE K-49
PORT SUMMARY - CANAL SYSTEM

PROJECTED RANGE OF WATERBORNE COMMERCE

	1970	1980	2000	2020
Millions of Tons	2.7	2.7 - 3.8	2.0 - 3.1	1.8 - 3.5

DEVELOPMENT PROGRAM

Not determined. See paragraph below.

The Canal System has not been considered as a whole because its development would be so expensive that it could not be reasonably considered. The improvement of the Canal System between Oswego and Troy, which is the shortest component linking the Hudson River and the Great Lakes, may be feasible, particularly in conjunction with recreational boating. However, opposition of the State and other local interests and intense competition of competing modes of transportation make a solely commercial improvement appear unlikely. Further study of major improvements for the canal system is recommended only when supported by the State of New York.

RECREATIONAL BOATING

The Hudson River is large and calm enough for all types of boating including sailing. There are more than 100 facilities along the Hudson, with 50 launching facilities and permanent berths or moorages for 2,600 craft. Table K-50 clearly shows the strong growth anticipated for recreational boating in Area 12, because of the available water and the Area's proximity to the New York City metropolitan area.

The Canal System has long been extensively used for recreation and has substantial recreational development. There are about 180 marinas and landings along the system with more than 50 launching facilities and approximately 5,000 permanent and temporary berths. Improvements for recreational boating would be restricted to berths and launching facilities until such time as the lockage capacity of the canal is approached. The lockage demand on the canal is determined by both commercial and recreational boating. It should be noted that one of the critical locks may be

Troy Lock, which must accommodate projected lockages for traffic on the Great Lakes to Hudson River Waterway as well as the Champlain Canal. Future studies should be conducted to determine possible lock improvements when it becomes apparent that lock capacity will be exceeded.

TABLE K-50
SUMMARY - AREA 12

COMMERCIAL NAVIGATION

PROJECTED RANGE OF WATERBORNE COMMERCE

	1970	1980	2000	2020
Millions of Tons	29.3	33.8 - 36.3	51.0 - 58.1	78.7 - 93.7

INITIAL CAPITAL COSTS

	1980	2000	2020
Millions of Dollars	-	80	27

RECREATIONAL BOATING

PROJECTED PLEASURE CRAFT

	1970	1980	2000	2020
Registered Craft*	50,000	60,000	83,300	115,000
Total Craft	71,000	127,000	186,000	320,000

*Vermont, Connecticut, New York & New Jersey - All motor boats; Massachusetts - 5 or more hp.

INITIAL CAPITAL COSTS
(millions of dollars)

	1980	2000	2020
Berths	2.6	6.0	8.2
Launching Facilities	1.1	1.2	3.3
Lock Improvement		Not determined	

Area 13

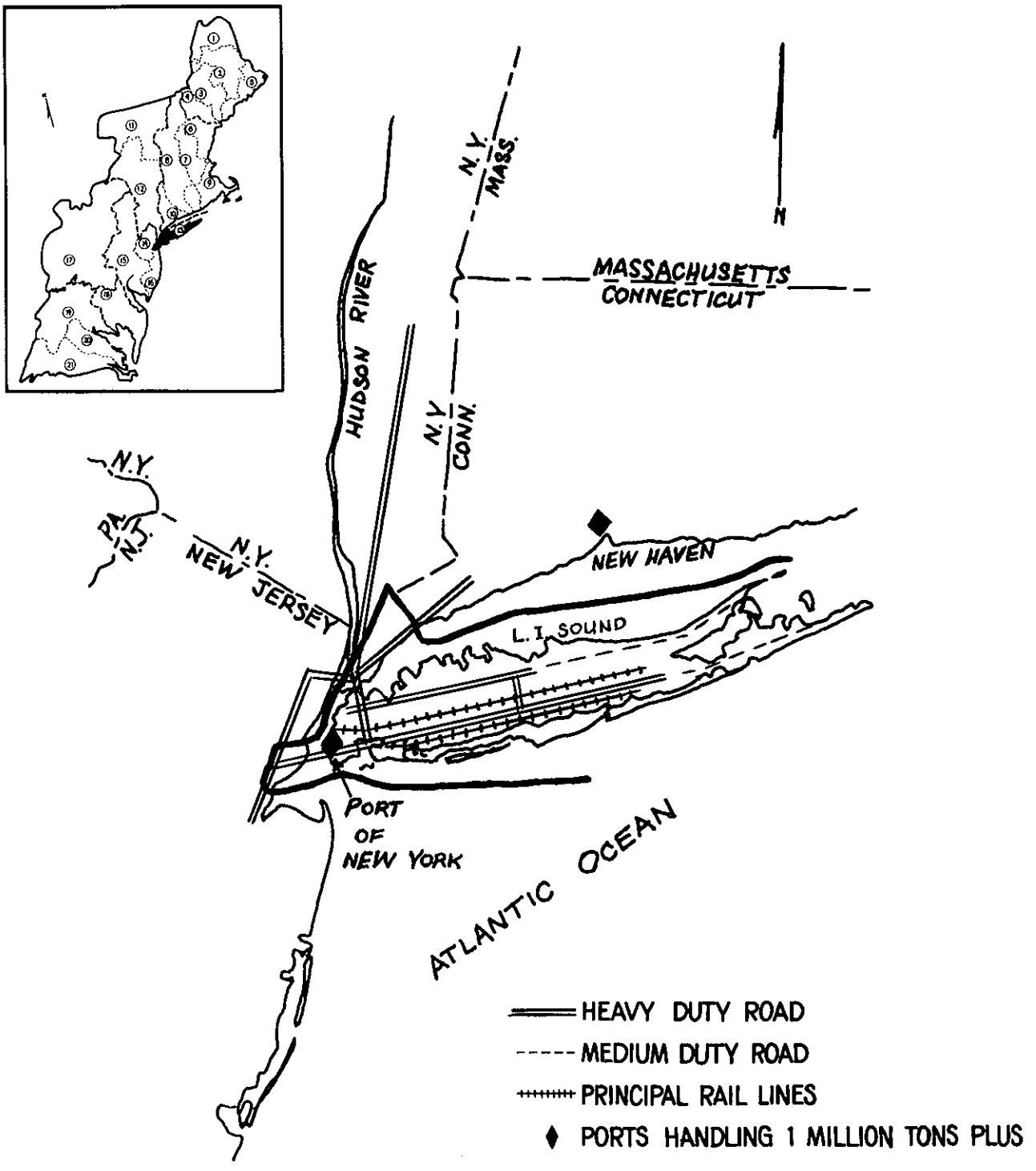


FIGURE K-24

AREA 13. SOUTHEASTERN NEW YORK METROPOLITAN AREA

Commercial navigation and recreational boating activities in Area 13 are among the highest in the Region and are expected to continue in this relative standing through 2020. Commercial navigation is based primarily in the western portion of the Area and is a significant aspect of the landscape. Continued programs for harbor maintenance and debris removal are a necessity in the Port area. Recreational boating is extensive along Long Island, and problems relating to pollution, overcrowding and public access and facilities can be anticipated.

Land Transportation

The development of the highways and railroads in Area 13 certainly support navigation development, but are not considered strongly complementary because of metropolitan congestion and bottlenecks. All traffic entering or leaving Area 13 must pass through a portion of New York City, except during the summer when motor vehicles can take advantage of ferry services operated on Long Island Sound. The railroad may be the best form of year-round transportation because special bridges and tunnels provide expedient passage from New York City to multiple and single tracks which extend the length of Long Island along each of its shores and through its central area. Figure K-24 clearly shows that high-speed, heavy-duty highways are found in the central and western portions of Long Island, but there is no high-speed movement in the vicinity of New York City. A petroleum pipeline extends from Area 14 to Jamaica Bay in the vicinity of Kennedy Airport on the South Shore of Long Island. Rail and highway movement is very good to population centers outside of Area 13.

Waterways

As shown on the map, Area 13 is a long narrow island. Long Island Sound lies to the north, the East River and New York Bay to the west, and the Atlantic Ocean to the south and east. Long Island Sound has natural depths well in excess of 80 feet, only a few hundred feet from the shore in many locations. The East River and New York Bay have been improved extensively. Minimum depths in the East River's main channel are 35 to 40 feet, 40 to 45 feet in the upper Bay, and 45 feet in the lower Bay. The South Shore of Long Island is separated from the deep water of the Atlantic Ocean by an extensive barrier beach system and wide shallow bays.

The waterways of Area 13 are extremely favorable to navigation because they are interconnected, and provide well-protected access to Areas 8, 9, 10, 11, 12 and 14. The tide range is approximately 5 feet.

Reported vessel traffic follows National trends. The number of tankers has remained approximately constant since 1955, but the commerce transported has increased several million tons, indicating the use of larger ships. Cargo vessel trips have fallen off by 90% since 1955, and barge traffic has declined by 60%, reflecting the use of vessels of greater capacity and increased harbor efficiency which is reducing local inter-harbor transfers.

Service Factors

Production in Area 13 does not support waterborne commerce because there is primarily light manufacturing in metals and plastics, and large manufacturing in textiles. While textiles are high value cargo and could possibly be very profitable to shippers in terms of tonnage, their movement is insignificant.

In Area 13, the demand for and consumption of commodities supports navigational development to a degree unequaled anywhere else in the United States. Over 9 million people live within 10 miles of the port facilities of New York City alone, creating an effective average density of 26,000 per square mile. A commodity used only occasionally by the average individual may be a commodity that can be profitably shipped when its demand is being generated by so many individuals.

COMMERCIAL NAVIGATION

Commodity Distribution

Table K-51 displays the major commodities of the portion of the Port of New York located in Area 13. These figures can be manipulated to support almost any desired trend. Commerce in the Port of New York has experienced only minimal growth, a fact substantiated by examination of the total commerce statistics for Area 13. Over the 14-year period, 1955-1968, total waterborne commerce increased at an annual average rate of only 0.4%. However, an examination of its major components -- total oceanborne, total internal, and total local -- tells a somewhat different story. Total oceanborne commerce increased at an annual average rate of 3.3% through the 1955-1968 period. This was a slight decrease from the 11-year period prior to 1966, when the growth averaged 4.4%. Internal traffic has been increasing erratically, and local transfers have been decreasing steadily, suggesting a significant increase in the commodity-handling efficiency of the Port.

Additional trends are apparent from Table K-51. Since 1955, foreign imports have been rising annually at an increasing rate, which by 1967 was 5.8%. At the same time, foreign exports have been decreasing and their annual rate of decline was 2% by 1967.

TABLE K-51
COMMODITY DISTRIBUTION - AREA 13

		1955		1965		1968	
Total - in 1000's of tons		58,550	100%	57,940	100%	61,900	100%
Total Oceanborne 1/		18,250	31%	25,840	44%	26,600	43%
Total Internal 2/		7,900	13%	3,900	7%	9,500	15%
Total Local 3/		32,400	55%	28,200	48%	25,800	42%
Residual Fuel Oil	F/I	2,624	4%	8,164	14%	9,376	15%
Coal	D/I			1,200	2%	1,473	2%
Sugar	F/I	854	1%	648	1%	675	1%
Distillate Fuel Oil	F/I			70		663	1%
Coffee	F/I	408	1%	494	1%	594	1%
Machinery	F/E	346		547	1%	473	1%
Food, meat, fruit juices	F/I	180		315		468	1%
Distillate Fuel Oil	D/I	600	1%	900	1%	443	
Sand & Gravel	D/I	913	1%	668	1%	394	
Copper	F/I	150		175		332	
Chemicals	F/E	217		211		298	
Iron	F/I	26		264		275	
Iron	F/E	572	1%	249		252	
Bananas	F/I	125		179		219	
Cement	F/I			85		210	
Motor Vehicles	F/E	437		283		210	
Rock	F/I	256		239		206	
Machinery	F/I			107		191	
Crude Petroleum	F/I			160		188	
Lumber	F/I	122		124		173	
Rubber	F/I	231		140		160	
Cooking Oils/Fats	F/E	92		162		152	
Cooking Oils/Fats	F/I	108		92		130	
Plastics	F/E			96		130	
Residual Fuel Oil	D/E	883	1%	285		116	
Food	F/E	344		257		108	
Copper	F/E	59		70		104	
Paper	F/E	83		97		103	
Textiles	F/E	117		122		100	
Lumber	D/I	289		167		98	
Fabricated Metals	F/I			60		90	

F = Foreign, D = Domestic, I = Import, E = Export.

1/ Total Oceanborne includes all foreign and domestic commerce transported over the ocean.

2/ Total Internal includes all commerce carried over inland waters plus material not originating in a port such as sand and gravel mined in a near shore area, and material not destined for a port such as solid waste which is disposed of at sea.

3/ Total Local includes all transfers of commerce from one port facility to another in the same port, but in this case includes the entire port of New York, portions of which lie in Areas 12, 13 and 14.

Finally, each commodity in turn can be examined but long-term extrapolation of past performance is unreliable on a port basis. The Regional Summary (Chapter 4), in this Appendix discusses the outlook for the major commodities handled in the North Atlantic Region. Power companies in Area 13 are the largest coal consumers and they have indicated that they intend to close coal burning power plants by the mid-1970s. It should be noted that reported commerce in Area 13 does not reflect the unreported commerce to two ports on Long Island, Northport and Northville.

Approximately 20 commodities are listed in Table K-51 in quantities large enough to be shipped in 30,000 to 200,000 d.w.t. vessels.

Major Ports

Most of the major port facilities of Area 13 are a part of the Port of New York.

East River. The East River connects Long Island Sound with Upper New York Bay. It is a 16-mile channel, generally 35 feet deep and 1,000 feet wide. It passes through the heart of New York, with spur channels designed for barge traffic leading into adjacent creeks and rivers, such as the Harlem River. From Upper New York Bay to the Brooklyn Naval Yard on the East River, a distance of 2.5 miles, the channel has a depth of 40 feet. Excluding facilities at the Brooklyn Naval Yard, there are about 140 wharves or piers along the East River, more than 30 of which have adjacent depths compatible with the depth of the waterway. They are used for general cargo, coal, sugar and fuel oil and are supported by petroleum storage of 250,000 tons (90% accessible to wharves with adjacent depths of at least 37 feet), and covered storage of 1.8 million square feet. Many rapid transit tunnels and aqueducts cross the East River limiting channel dredging to about 40 feet below mean low water. Pipelines and cables cross the river and generally lie on or near the existing river bottom. Bridges provide at least 700 feet of horizontal clearance and 127 feet of vertical clearance.

Upper New York Bay. Upper New York Bay is generally 40 or more feet deep because of the extensive channel and anchorage development throughout. The portion located in Area 13 includes the Buttermilk, Red Hook and Bay Ridge Channels, which are all 40 feet deep. There are about 75 facilities along these channels, 18 of which have adjacent depths of 35 feet or more, and several are served by rail. They are supported by 5.5 million square feet of covered storage, and tend to be specialized for general cargo or marine repairs. Gowanus Creek, an offshoot of the Bay Ridge Channel has depths declining in stages from 30 feet to 9 feet. Along Gowanus Creek, there are about 60 facilities, most of which are designed for barges, although two have adjacent depths of 35 feet. These facilities are supported by covered storage of 1 million square feet and petroleum storage of 12,000 tons.

North Shore of Long Island. Long Island Sound provides much calmer passage than the open ocean; however, its potential hazards cannot be overlooked. It is more than 100 miles long in a direction which generally corresponds to storm tracks, thereby making it susceptible to severe waves and turbulence. Along the western portion of the Island's North Shore, there are about a dozen large bays which have natural depths of 20 feet. Access channels to these bays have depths generally from 9 to 12 feet. The bays are used primarily by commercial traffic, but several, including Manhasset Bay, are extensively developed as recreational areas.

The central and eastern portions of the North Shore of the Island are fairly regular, and characterized by water over 60 feet deep lying within a few hundred feet of the shore. An offshore facility in this area now handles over 2 million tons of petroleum products annually, most of which is redistributed by barge to Connecticut.

South Shore of Long Island. The South Shore is formed by a narrow barrier beach extending the length of the Island, and broken in a half dozen places by tidal inlets. Behind this barrier beach, there are five rectangular bays, generally less than 5 feet deep, but interconnected by a dredged 6-foot channel. Along these bays, there are several facilities designed to handle barge traffic carrying petroleum, sand, gravel and solid wastes through access channels which are generally 9 feet deep. Any study for improvements in this area should fully explore potential ecological problems.

At the eastern end of the Island is a highly irregular bay partially protected by its shape and by an island across its mouth. Because of the distance to urban areas, there has been very little development along its shores. Several harbors report commercial traffic, but recreational boating is economically more important. The depth in the bay varies between 10 and 40 feet.

Waterborne commerce projections for Area 13 are based on the differential growth rates and trends of imports, exports, domestic, local and internal commerce. Prospective commerce is expected to increase at an annual rate between 0.7% and 2.5%.

No development plan is recommended for the South Shore of Long Island as it is not well suited to commercial navigation and the Island is so narrow that harbors on the more favorable North Shore can satisfy the needs.

TABLE K-52
PORT SUMMARY - AREA 13

PROJECTED RANGE OF WATERBORNE COMMERCE

	1970	1980	2000	2020
Millions of Tons	61.9	66.2- 79.2	76.1-130.0	87.9-212.5

DEVELOPMENT PROGRAM 1/

	1970	1980	2000	2020
East River				
Channel Depth (ft)	35	-	45	-
Improvement Cost ($Millions)	-	-	18	-
North Shore of L. I.				
Channel Depth (ft)	20	35-60 2/	-	-
Improvement Cost ($Millions)	-	30	-	-

1/ Any development plan should consider a regional port facility.

2/ Program includes development of an eastern L. I. bay to a depth of 35 feet and an offshore petroleum facility in western L. I. with 60-foot depths.

RECREATIONAL BOATING

The population density and average income of Area 13 suggest that recreational boating can play an important part in satisfying recreational needs. The well-protected bays of the South Shore are the most naturally suited for intense recreational development. Its five bays are small enough to insure relatively calm water, but large enough to support the more popular recreational craft, that are most often stored at home and trailered to the water. As a consequence, emphasis should be placed on the development of launching facilities, parking areas and rest facilities. Relatively minor dredging will be necessary to establish nearshore depths of 4 to 5 feet. More than three-quarters of the more than 700 public facilities devoted to recreational boating are found along the South Shore.

The North Shore is better suited to larger recreational craft, with depths exceeding 6 feet in most areas and will be the most likely area for extensive marina and recreational harbor development.

Public recreational facilities in Area 13 include more than 27,000 permanent berths and moorages, and about 300 launching facilities.

TABLE K-53
RECREATIONAL SUMMARY - AREA 13

RECREATIONAL BOATING

PROJECTED PLEASURE CRAFT

	1970	1980	2000	2020
Registered Craft*	267,000	286,000	324,000	363,000
Total Craft	383,000	491,000	680,000	1,400,000

*All motor boats.

INITIAL CAPITAL COSTS
(millions of dollars)

	1980	2000	2020
Berths	4.9	10.0	10.2
Launching Facilities	2.0	3.8	14.4

TABLE K-54
SUMMARY - SUB-REGION C

COMMERCIAL NAVIGATION

PROJECTED RANGE OF WATERBORNE COMMERCE

	1970	1980	2000	2020
Millions of Tons	92.4	101.3-117.1	128.5-190.5	168.2-310.1

INITIAL CAPITAL COSTS

	1980	2000	2020
Millions of Dollars	30	98	27

RECREATIONAL BOATING

PROJECTED PLEASURE CRAFT

	1980	1980	2000	2020
Registered Craft*	340,000	371,000	436,000	511,000
Total Craft	477,000	646,800	910,500	1,786,000

*Vermont, New York, New Jersey & Connecticut - all motor boats; Massachusetts - 5 or more hp.

INITIAL CAPITAL COSTS
(millions of dollars)

	1980	2000	2020
Berths	7.5	16.1	18.6
Launching Facilities	3.5	6.3	19.1
Canal Improvements		Not determined	

SUB-REGION D

Sub-region D has the greatest commercial navigation activity of any of the NAR Sub-regions and can be expected to maintain this standing despite physical constraints and conflicts with landscape quality, water quality, land use and other water resource related needs. Recreational boating activity is about the highest in the Region, but presently faces localized overcrowding problems which will tend to become more serious.

COMMERCIAL NAVIGATION

Area 14 is extensively developed for commercial navigation and its further development will primarily consist of modernization, although there is an increasing need for improved access waterways. Area 15 is significantly developed for commercial navigation along the Delaware River with good potential for further development. A great potential exists in Delaware Bay for deep-draft port facilities including a Regional port. Area 16 does not have great potential for commercial navigation.

RECREATIONAL BOATING

Area 16 offers great potential for continued recreational boating development providing overcrowding is carefully avoided. Like Area 13, Area 16 includes extensive barrier beaches which protect long, wide, shallow bays ideal for boating. This Area also has numerous inlets which permit boating enthusiasts to easily enter and take advantage of the many recreational opportunities afforded by the Atlantic Ocean. It is well located with respect to New York and Philadelphia and is easily accessible. Area 15 boating will grow primarily on the rivers in the Area although there are some lakes. Water quality may inhibit the development of recreational boating in Area 14.

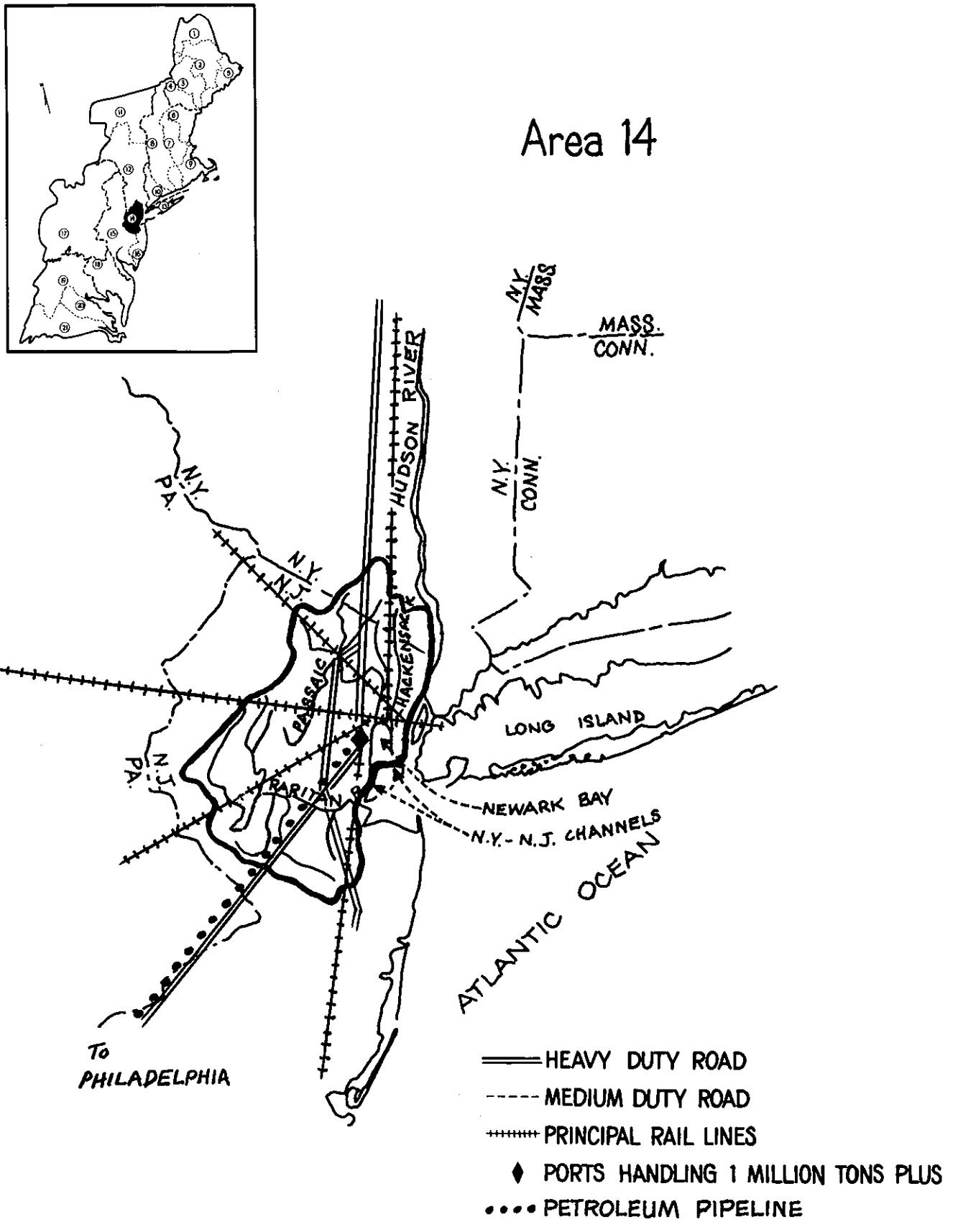

Area 14
N.Y./MASS.
MASS./CONN.
N.Y./CONN.
HUDSON RIVER
N.Y./PA.
N.Y./N.J.
PASSAIC
HACKENSACK
LONG ISLAND
N.J./PA.
RARITAN
NEWARK BAY
N.Y.-N.J. CHANNELS
ATLANTIC OCEAN
To PHILADELPHIA
HEAVY DUTY ROAD
MEDIUM DUTY ROAD
PRINCIPAL RAIL LINES
PORTS HANDLING 1 MILLION TONS PLUS
PETROLEUM PIPELINE

FIGURE K-25

Commercial navigation is one of the most important activities of Area 14, and its waterborne commerce is at one of the highest levels in the Region. Commercial navigation directly supports industries which are major water users, including several power companies. Area 14, together with Areas 12 and 13, is the focus of current pier, abandoned ship and drift removal programs designed to reduce general hazards to navigation and improve the quality of the landscape. Recreational boating can be expected to increase moderately if water quality is improved.

Land Transportation

Land transportation tends to support navigation in Area 14. Multiple rail lines extend in all directions, linking Area 14 to every major city in the Region and the major rail systems to the north, west and south. Large rail switching yards are located within minutes of the port facilities. Several multiple-lane, heavy-duty, high-speed roadways provide north-south movement, but the construction of east-west roadways is incomplete. Pipelines for petroleum and natural gas extend into Area 14 from the south and west and provide for the movement of millions of tons of fuels annually. Petroleum pipelines extend from Area 14 to Area 13 to satisfy airport fuel requirements. (See Figure K-25).

Waterways

Most of the principal waterways of Area 14 are commercially developed and have dimensions suitable for deep-draft vessels. Newark Bay has a project depth of 35 feet for its entire length. The Hackensack and Passaic Rivers, which empty into Newark Bay, have depths ranging from 10 to 32 feet. The Raritan River, which empties into Lower New York Bay, varies from 25 to 10 feet as one progresses upriver.

The New York and New Jersey Channels have depths generally to 35 feet, although 36-foot draft vessels safely navigate the waterway on high tide. Arthur Kill, the north-south leg of the channels, cannot be deepened without extensive rock removal in its northern reaches or widened without complete channel modifications. Thus, further navigation development by deepening or widening would be very costly. Kill Van Kull, the east-west leg of the N.Y.-N.J. Channels, offers no width restriction but is also grounded in rock. Improvements to Newark Bay have encountered rock.

While the waterways of Area 14 and its adjacent Areas give Area 14 an overwhelmingly powerful and centralized location for the redistribution of waterborne commerce, their development restrictions neutralize the advantage to a great extent.

Service Factors

Extensive industrial development has occurred in Area 14 for the refining of petroleum. This industry acts as a stimulus for navigation both in consumption and production. Besides being a center for redistribution of domestically-refined petroleum products such as gasoline, it is also important for the chemical by-products of its refineries. Sand, gravel and stone are major commodities by weight. Other industries, which contribute to waterborne commerce, are the textile and machinery industries.

Demand for commodities is generated by 4.6 million people in the immediate area, in concentrations as high as 12,000 per square mile. Thus the population, density, and location is very favorable to navigation development.

COMMERCIAL NAVIGATION

Commodity Distribution

The most significant trend exhibited by commodity distribution, as shown in Table K-55, is the increasing commodity diversity which is very favorable for continued growth.

TABLE K-55
COMMODITY DISTRIBUTION - AREA 14

		1955		1965		1968	
Total - 1000's of tons		95,320	100%	110,560	100%	128,800	100%
Residual Fuel Oil	F/I	15,930	17%	22,770	20%	28,700	22%
Crude Petroleum	FD/I	17,522	18%	17,374	16%	18,631	14%
Distillate Fuel Oil	LD/E	25,510	27%	21,520	19%	24,150	19%
Gasoline	LD/E	16,150	17%	17,030	15%	17,020	13%
Waste-Sea Disposal	L					6,800	5%
Kerosene/Jet Fuel	F/I	1,300	1%	6,000	5%	5,800	4%
Petroleum by-products	LD/E	2,400	2%	5,100	5%	5,400	4%
Coal	L	6,600	7%	6,100	5%	5,280	4%
Chemicals	D/EI	1,300	1%	2,000	2%	2,300	2%
Construction Materials	D/I	681	1%	645		1,100	1%
Iron	F/I	439		380		810	
Iron Scrap	F/E			661		714	
Stone	F/I	790		307		477	
Copper	F/I	370		344		482	
Lumber	F/I	383		362		334	
Motor Vehicles	F/I			238		336	
Machinery	F/E	18		150		329	
Food/Juices	D/I	185		197		234	
Meat, Coffee,Bananas	F/I	10		352		410	

F = Foreign, D = Domestic, L = Local, I = Import, E = Export.

Major Ports

Hudson River. The Hudson River below the George Washington Bridge is included in Area 14 because most of the commerce is now handled through New Jersey. The Federal project provides a 40-foot deep channel for the full width of the river extending from Upper New York Bay to 59th Street. A 2,000-foot wide section of this project has been deepened to 45-48 feet. Above 59th Street, a natural channel extending 600 feet wide and 32 feet deep is a part of the Hudson River, N.Y.C., to Waterford project. A channel to the Weehawken-Edgewater waterfront is 30 feet deep and 750 feet wide. Along its shores are 260 facilities, almost all for handling general cargo. About 10% have depths compatible to the waterway. The facilities are supported by covered storage (5 million square feet), storage for cooking oils (105,000 tons), and petroleum storage (120,000 tons, less than 30% accessible to vessels drawing over 21 feet). There are a number of rapid transit tunnels and aqueducts which cross the River, but none are shallower than 52 feet below mean low water. Commerce has been declining at an accelerating rate. It declined at an average annual rate of 3.5% for the 19 years ending in 1967, and declined at a rate of 4.5% during the last 10 of those years. Commerce on the Hudson River averaged 13,480,000 tons for the three years prior to 1968. The 1970 commerce was 8,850,000 tons.

Commerce will continue to decline unless major rehabilitation and development of piers and supporting facilities is accomplished. Contributing to the decline has been a large expanse of land just west of the Statue of Liberty in Jersey City, N. J. The major portion of the land is owned by railroads, whose operations in this area have greatly declined in the past decade. Jersey City has plans for buying this and adjacent lands, some owned by the Federal government, and effecting a major waterfront development both for industrial and residential purposes. The uncertainty as to the waterway users to locate in the Jersey City area and efforts to be undertaken for waterfront development in other communities along the Hudson River both in New York and New Jersey, make any projection of waterborne commerce and any proposed development plan meaningless. A study should be undertaken with a view to navigation improvements at such time as local government waterfront development plans become clear.

TABLE K-56
PORT SUMMARY - HUDSON RIVER

PROJECTED RANGE OF WATERBORNE COMMERCE

	1970	1980	2000	2020
Millions of tons	8.9	Not	determined.	

DEVELOPMENT PROGRAMS

Rehabilitate and develop waterfront facilities; costs not determined.

Newark Bay. Commerce in Newark Bay is mostly general and containerized cargo which is more sensitive to improvements in shore transshipment facilities than to additional waterway improvement. More than 30 facilities have adjacent depths of 35 feet and are supported by open and covered storage (4 million square feet), liquid storage (6 million gallons), and petroleum storage (400,000 tons). A railroad bridge restricts horizontal clearance to 200 feet at the entrance of the Bay.

Both tankers and dry cargo vessels with drafts exceeding the project depth of 35 feet were reported to have entered the waterway in 1970. The U. S. Department of Commerce Maritime Administration reports that general cargo vessels (container-type) are presently resting on the bottom of mean low water in Newark, N. J.

Waterborne commerce grew at an average annual rate of 3.5% for the 19 years ending in 1967 and increased to 4.8% during the last 10 of those years. Commerce averaged 11,800,000 tons for the three years prior to 1968. The 1970 commerce was 14,720,000 tons. The projected commerce reflects continued development of modern terminal facilities at Port Elizabeth. The annual growth rate ranging from 2.3% to 4.8% will be somewhat effected by developments along competing waterways such as the Hudson River.

TABLE K-57
PORT SUMMARY - NEWARK BAY

PROJECTED RANGE OF WATERBORNE COMMERCE

	1970	1980	2000	2020
Millions of Tons	14.7	18.5-23.5	28.4-60.0	45.8-60.0

DEVELOPMENT PROGRAM

	1970	1980	2000	2020
Channel Depth (ft)	35	40	-	-
Improvement Cost ($Millions)	-	35	-	-

New York-New Jersey Channels. There are approximately 200 wharves and piers along the 31 miles of the Kill Van Kull and Arthur Kill components of the N.Y.-N.J. Channels. About 90% are specifically designed for the receipt and/or shipment of petroleum products and are supported by petroleum storage (10 million tons). Only about 10% of the facilities have adjacent depths compatible with the depth of the waterway. Pipelines operating at about 45% capacity carried some 14.5 million tons of gasoline and distillate from the Gulf of Mexico to New York in 1969. Between 1967 and 1969, their delivered tonnage was increasing at a 4% annual rate. Tonnage carried in these pipelines is expected to grow at the same or a higher rate of growth as waterborne petroleum commerce over the next 10 years. Crude petroleum and residual fuel oil generate most of the pressure for deepening and widening of the waterways.

Vessel traffic entering the N.Y-N.J. Channels is encouraged to enter Kill Van Kull and exit via Arthur Kill. This procedure has prevented serious traffic jams from occurring. Vessel traffic is dominated by tankers whose dimensions allow no doubt that the channel has inadequate depth. Approximately 1,400 vessels have been reported annually for the last 15 years having drafts greater than 30 feet. In 1955, no vessels had to utilize tide to approach the facilities. In 1965, almost 20% of those vessels required tide to use the channels, and in 1968 this increased to almost 33%. Vessels entering Newark Bay generally use Kill Van Kull as an entrance channel.

Waterborne commerce grew at an average annual rate of 1.5% for the 19 years ending in 1967, but its average growth increased slightly to 1.8% during the last 10 of those years. Commerce averaged 85 million tons for the three years prior to 1968. The 1970 commerce was 93,990,000 tons. The annual growth rate is expected to range from 1.5% to 2.5%.

Due to the extensive rock dredging required to improve the entire waterway, future studies should consider improvement of selected reaches of the waterway.

TABLE K-58
PORT SUMMARY - NEW YORK - NEW JERSEY CHANNELS

PROJECTED RANGE OF WATERBORNE COMMERCE

	1970	1980	2000	2020
Millions of Tons	94.0	109.0-120.4	146.8-197.5	198.2-323.0

DEVELOPMENT PROGRAM

	1970	1980	2000	2020
Channel Depth (ft)	35	45 1/	(+)	-
Improvement Cost ($Millions)	-	50	-	-

1/ Alternative program - Consideration of offloading facility in Lower Bay. Approach channel depths of 60 feet in 1980 and 80+ feet in 2000. Estimated cost $130 million in 1980 and $70+ million in 2000. Any program must provide for depths of 40 feet in Kill Van Kull to accommodate Newark Bay traffic (Table K-57).

Hackensack and Passaic Rivers. There are about 100 facilities along the navigable portions of the Hackensack and Passaic Rivers, which are generally equipped to handle sand, gravel or petroleum. At the mouth of both rivers, many facilities are devoted to marine salvage. Many bridges cross the rivers, limiting the horizontal clearance to less than 100 feet.

Commerce grew steadily at an average annual rate of about 1% for the 19 years ending in 1967. Commerce averaged 14,600,000 tons for the three years prior to 1968. The 1970 commerce was 14,040,000 tons. The annual growth rate is expected to range from 1% to 2.5%.

TABLE K-59
PORT SUMMARY - HACKENSACK-PASSAIC RIVERS

PROJECTED RANGE OF WATERBORNE COMMERCE

	1970	1980	2000	2020
Millions of Tons	14.0	15.4-17.0	18.9-29.4	23.0-48.2

DEVELOPMENT PROGRAM

	1970	1980	2000	2020
Channel Depth (ft.)	32-10	35-20	-	-
Improvement Cost ($Millions)	-	10	-	-

Raritan River. Fuels have dominated the commerce carried over the Raritan River for many years because of the petroleum-oriented facilities near its mouth, and inland electric power plants. Seventeen wharves/piers are found along the 300-foot wide, 25-foot deep, channel which extends 6 miles upriver from Lower New York Bay. They include special handling facilities for coal, chemicals and petroleum, and are supported by petroleum storage totaling almost 1 million tons. Waste disposal has contributed one-third of the commerce during 1968 and 1969. Vessels of 10-foot draft can negotiate an additional 10 miles upriver. A current study is considering the construction of a flood control and water supply dam across the river in the vicinity of Crab Island. No provision for passage of commercial traffic is foreseen at this time. Thus, the development program for commerce has been limited to consideration of improvements downstream of Crab Island.

Raritan River commerce grew steadily at an average annual rate of about 2% for the 19 years ending in 1967. Commerce averaged 8,000,000 tons for the three years prior to 1968. The 1970 commerce, however, dropped to 7,810,000 tons. In projecting the commerce the figures from 1967 through 1969 were discounted as they are unusually high.

RECREATIONAL BOATING

Considering the population of Area 14, recreational boating is not well developed. This is believed to be due, in part, to poor water quality and the great amount of commercial navigation activity in the Area. Three-fourths of the development has taken place on the Raritan

River. There are approximately 1,500 permanent berths or moorages in the Area, and 25 launching facilities spread among the more than 60 public boating facilities.

Future studies should investigate the feasibility of improving water quality and providing for joint use of the waterways by recreational and commercial vessels. As an alternative, the interests of recreational and commercial navigation might best be served by zoning the waterways of Area 14 for the exclusive use of one or the other. Then, those portions set aside for recreational boating, perhaps the Raritan, Passaic, and Hackensack Rivers, or portions thereof, must have greatly improved water quality. Once these conflicts are on the way to being resolved, emphasis can be placed on the construction of recreational boating facilities. The very high population density should make such activity profitable, and it is therefore assumed that private enterprise will satisfy the needs.

In this regard, construction of the dam at Crab Island would in effect exclude commercial navigation from most of the Raritan River. The current study is giving consideration to provision of a lock for recreational vessels only.

TABLE K-60
PORT SUMMARY - RARITAN RIVER

PROJECTED RANGE OF WATERBORNE COMMERCE

	1970	1980	2000	2020
Millions of Tons	7.8	9.2-12.0	12.3-16.6	16.7-27.2

DEVELOPMENT PROGRAM

	1970	1980	2000	2020
Channel Depth (ft) 1/	25	35	-	-
Improvement Cost ($Millions)	-	4	-	-

1/ Below Crab Island.

TABLE K-61
SUMMARY - AREA 14

COMMERCIAL NAVIGATION

PROJECTED RANGE OF WATERBORNE COMMERCE 1/

	1970	1980	2000	2020
Millions of Tons	139.5	152.1-172.9	206.4-249.5	283.7-404.

INITIAL CAPITAL COSTS

	1980	2000	2020
Millions of Dollars	99 2/	2/	-

1/ Excludes projections of Hudson River commerce.
2/ Cost shown is for channel deepening only. Alternative costs for an offloading facility in N.Y.-N.J. Channels are $130 million in 1980 and $70 million in 2000.

RECREATIONAL BOATING

PROJECTED PLEASURE CRAFT

	1970	1980	2000	2020
Registered Craft*	90,000	100,000	129,000	162,000
Total Craft	135,000	188,000	270,000	430,000

*All motor boats.

INITIAL CAPITAL COSTS
(millions of dollars)

	1980	2000	2020
Berths	2.6	7.5	8.6
Launching Facilities	1.9	2.8	5.7
Crab Island Lock	4.2	--	--

AREA 15. DELAWARE RIVER BASIN

Navigation is among the most important factors in water resource planning for Area 15. Commercial navigation supports major water-using industries, including steel, iron and petroleum refining. Both commercial and recreational activities are strongly pursued and very active, but somewhat mutually exclusive. By the end of the planning period, this Area could rank first in commercial and recreational navigation if good solutions are found to overcome physical constraints and to resolve conflicts with water supply, land use and water quality.

Land Transportation

The map of Area 15 (Figure K-26) clearly shows Philadelphia as a center of land transportation from which multiple-lane, high-speed, heavy-duty roads and rail lines radiate in all directions. Land transportation is extremely complementary to commercial navigation. Philadelphia is one of the cities which is connected to the Colonial Pipeline System. While this normally would be a negative influence to navigation, it is a positive influence in Area 15 because it offers yet another means for large amounts of petroleum to be transported from Philadelphia, the greatest crude oil refining center on the Atlantic Coast. However, only a moderate expansion of pipeline facilities is foreseen due in part to increased hazards to public water supplies from potential pipeline failure.

Waterways

Navigation occurs only on rivers because Area 15 does not include ocean frontage except for the Delaware Estuary. The Delaware River is commercially navigable for well over 130 miles, providing access to such major cities as Philadelphia and Trenton, and an additional 100 miles for recreational boating. Natural dimensions have been improved to 40 feet beyond Philadelphia to a point about 5 miles south of Trenton, N. J. The authorized depth for the 5 miles is 35 feet, but the work in this section has been placed in the deferred category because local interests have not provided terminal facilities adequate for such a depth. The Schuylkill River empties into the Delaware at Philadelphia, and is navigable for about 45 miles upstream. However, Fairmont Dam, about 5 miles above the confluence, interrupts continuous navigation.

The Chesapeake and Delaware Canal, at the head of the Delaware Estuary, is a man-made waterway which was authorized to 35-foot depth to shorten the distance for transit between Baltimore and Philadelphia by about 300 miles. However, controlling depth in the canal is 27 feet.

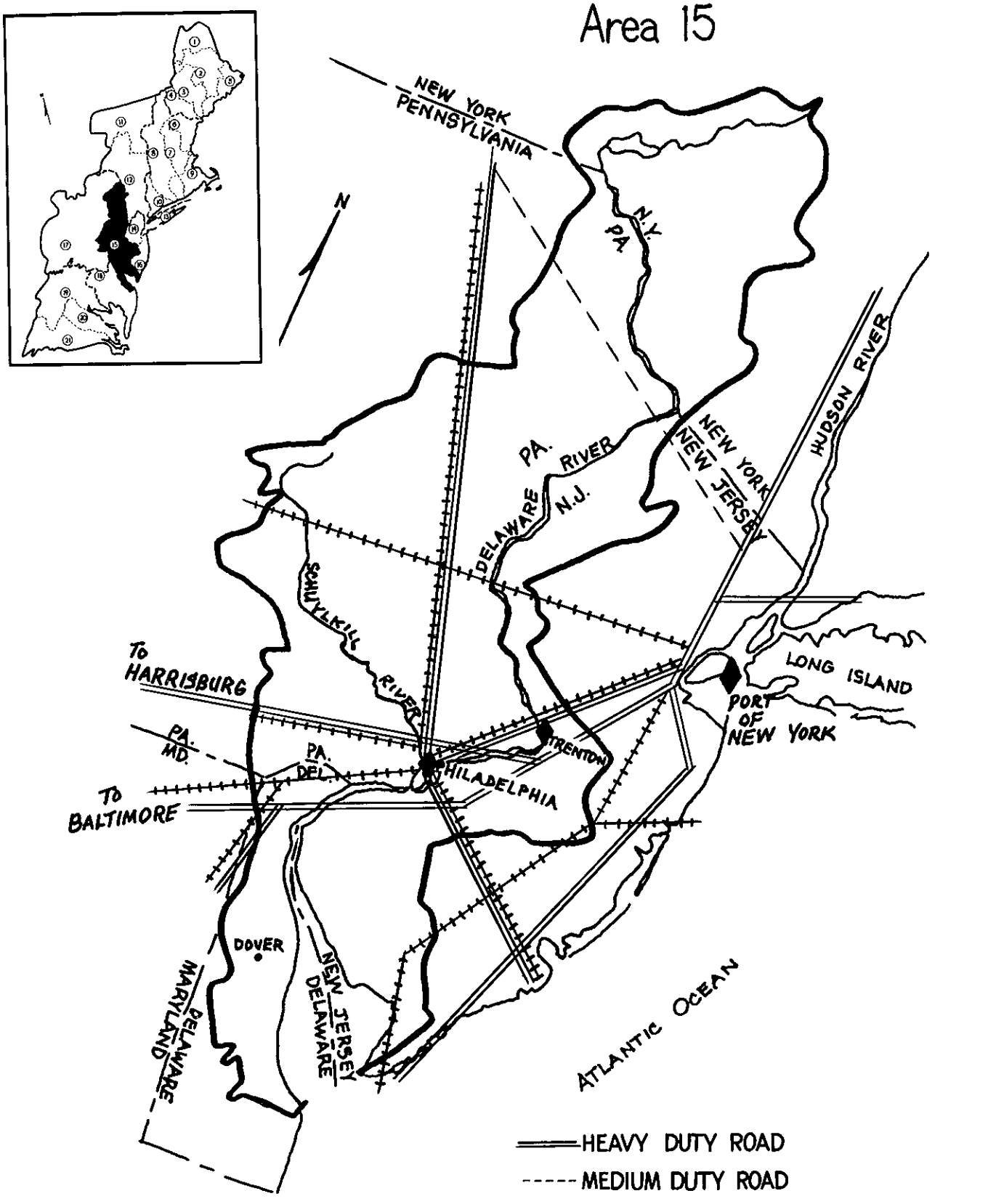

Area 15
NEW YORK
PENNSYLVANIA
N
N.Y.
PA.
PA.
DELAWARE
RIVER
N.J.
NEW YORK
NEW JERSEY
HUDSON RIVER
SCHUYLKILL
RIVER
TO
HARRISBURG
PA.
MD.
PA.
DEL.
TRENTON
PHILADELPHIA
TO
BALTIMORE
LONG ISLAND
PORT
OF
NEW YORK
DOVER
MARYLAND
DELAWARE
NEW JERSEY
DELAWARE
ATLANTIC OCEAN
HEAVY DUTY ROAD
MEDIUM DUTY ROAD
PRINCIPAL RAIL LINES
PORTS HANDLING 1 MILLION TONS PLUS

FIGURE K-26

The waterways of Area 15 are relatively free from storm hazards, but have significant physical obstructions to deepening because much of the channel is based on rock. Significant deepening of the river below Philadelphia may interfere with good-water conditions and community water supplies. Studies will have to be undertaken to determine if these potential hazards are real.

Trends of reported vessel traffic clearly suggest the waterway is presently inadequate. Since 1955, the total number of self-propelled vessels reported annually has remained constant; while during the same period, tonnage increased some 30 million tons. The number of vessels reported to have required tide to reach port facilities jumped from zero in 1955 to almost 300 in 1968.

Service Factors

Many of Area 15's major products, by weight or by volume, are potentially very complementary to navigation. They include cement, which is produced on the order of 2 million tons annually, and coal, which is produced on the order of 60 million tons annually. Both cement and coal have generally been shipped by rail or truck to nearby States, as have most of the machinery, metals and textiles.

It is the consumption needs of industry which strongly support navigation, requiring iron ore and petroleum by the tens of millions of tons annually. The contined ability of these industries to compete in the World market will depend to a great degree on the navigation development undertaken in the immediate future.

Commodity demand is also a major factor in the support of navigation as it is generated by 6.4 million people; more than a third of whom live in Philadelphia in concentrations of more than 15,000 per square mile.

COMMERCIAL NAVIGATION

Commodity Distribution

Table K-62 shows the distribution of the waterborne commerce on the Delaware River. About one-half of the commerce are bulk commodities, whose transportation costs are most sensitive to channel improvements, especially deepening. About one-fifth of the commerce is general cargo, which is most sensitive to shore facility improvements. The remaining commerce, which includes such commodities as sand and gravel, will not benefit greatly by further navigation development.

TABLE K-62
COMMODITY DISTRIBUTION - AREA 15

		1955		1965		1968	
Total - 1000's of tons		88,000	100%	107,000	100%	116,000	100%
Crude Petroleum	F/I	35,234	40%	38,620	36%	44,500	38%
Iron Ore	F/I	7,424	8%	15,168	14%	10,646	9%
Residual Fuel Oil	F/I	2,325	3%	5,340	5%	7,674	7%
Gasoline	D/E	1,842	2%	4,478	4%	4,173	4%
Distillate Fuel Oil	D/I	2,225	3%	2,817	2%	3,123	3%
Oils	F/E	1,000	1%	2,000	2%	1,227	1%
Iron	F/I	900	1%	660		1,100	1%
Sugar	F/I	790		867		1,000	1%
Coal	FD/E	1,970	2%	1,691	1%	800	
Kerosene/Jet Fuel	D/E	199		432		548	
Chemicals	D/I	436		300		340	
Lumber	F/I	497		467		441	
Grains	F/E	500		700		400	
Residual Fuel Oil	L	2,267	2%	4,602	4%	7,210	6%
Crude Petroleum	L	3,101	3%	2,416	2%	6,730	6%
Gasoline	L	5,129	6%	3,689	3%	4,642	4%
Distillate Fuel Oil	L	4,702	5%	3,379	3%	4,273	4%
Coal	L	3,151	4%	4,304	4%	3,692	3%
Sand and Gravel	L	4,309	5%	3,651	3%	3,060	3%
Kerosene/Jet Fuel	L	368		868		1,567	1%
Chemicals	L	800		1,100	1%	975	1%
Oils	L	863		620		570	
Grains	L	240		473		451	
Iron	L	406		294		450	
Rock	L	362		354		404	
Pulp	L	246		371		189	
Lumber	L	417		286		163	

F = Foreign, D = Domestic, L = Local, I = Import, E = Export.

Major Ports

Chesapeake and Delaware Canal. The C & D Canal is a 17-mile land-cut linking the Delaware River to Chesapeake Bay. Providing the authorized depth of 35 feet will require channel improvements over a distance of about 45 miles. The controlling channel depth is presently 27 feet. A monitoring system will be set up to evaluate the hydrologic changes which are expected to include a change in the salinity regime of Upper Chesapeake Bay.

The commerce reported for the Canal is not added to the figures shown for the commerce of Areas 15 or 18 to avoid duplication of commerce. Commerce grew at an annual average rate of 1.8% for the 19-year period ending in 1967 but at the slightly less rate of 1.5% during the last 10 of those years. Commerce averaged 10,500,000 tons for the three years

prior to 1968. The 1968 commerce was 9,610,000 tons, composed of coal, chemicals, lumber, paper, coke, grains, machinery, building materials and petroleum. It is expected that coal and petroleum movement will increase significantly when the 35-foot depth is provided.

It is unlikely that further deepening will be contemplated for the Canal because of the tremendous expenditures that would be required in relation to the tons of cargo moved by 2020. If the present distribution of commerce were to continue through 2020, the 35-foot deep Canal would have a capacity of over 100 million tons annually. If present commerce were to grow at an annual compounded rate of 2.5%, it would be just under 25 million tons by 2020.

Delaware Bay. Commerce in lower Delaware Bay, excluding all traffic which merely passes through to destinations elsewhere, has suffered an immense decline over the last 25 years. Commerce declined at an annual rate of 13% between 1958 and 1967. Population of the counties flanking the Bay has increased by at least 18% during this decade.

There are dozens of recreational harbors and marina-type sites along the circumference of the Bay and many small rivers which support boating. The Cohansey and Salem Rivers are navigable by vessels drawing up to 17 feet at high tide, and provide navigation inland as far as 19 miles. In the early-1950s, these rivers passed hundreds of thousands of tons of petroleum products, but at present they handle less than 50,000 tons. Fish, shellfish and farm products were reported on the order of tens of thousands of tons in the early-1950s,but are now reported in terms of hundreds of tons.

When commerce is less than 100,000 tons, it cannot be projected reliably because normal year-to-year fluctuations are often greater than the highest estimate for any of the projected bench mark years. Bay commerce is less than 0.1% of the present commerce of Area 15, and this relationship is not expected to change unless an offshore terminal is constructed in the Bay. No commerce projection is made because any figures based on growth rates would lie well within the margin of error of the other projections of Area 15.

All planning objectives will be supported by a development program which emphasizes the improvement of shore facilities and encourages recreational and commercial fishing activity.

Delaware River - Bay to Philadelphia. The 90-mile, 1,000-foot-wide, 40-foot-deep waterway to Philadelphia provides access to 14 principal port areas including a portion of the Ports of Philadelphia. About one-half of the commerce reported in this stretch of the river is delivered to Philadelphia. Excluding the portion of Philadelphia included in this stretch of the river, there are approximately 60 piers and wharves along the main channel, located primarily between the 60- and 80-mile points. Major facilities in the reach below Philadelphia serve crude petroleum, petroleum products, chemicals and ship repair yards.

Waterborne commerce has grown at an average annual rate of 3.3% for the 19 years ending in 1967, but at only 1.2% during the last 10 of those years. Commerce averaged 86,900,000 tons for the three years prior to 1968. Commerce in 1970 was 99,000,000 tons. Projections of commerce are shown in Table K-63. The high projections assume changes in import quotas.

TABLE K-63
PORT SUMMARY - DELAWARE RIVER (BAY TO PHILADELPHIA)

PROJECTED RANGE OF WATERBORNE COMMERCE

	1970	1980	2000	2020
Millions of Tons	99.0	110-173	158-213	230.0-350.0

DEVELOPMENT PROGRAM

	1970	1980	2000	2020
Channel Depth (ft)	40	70+1/	80-44 2/	-
Improvement Cost ($Millions)	-	300+	350	-

1/ Construction of off-loading facilities for Delaware River Commerce, either offshore or in the bay.

2/ Deepening channel to off-loading facility to 80 feet, and river channels to 44 feet.

Philadelphia. Gloucester City, Camden and Philadelphia include 22 miles of port-developed waterfront on the Delaware River known as the Ports of Philadelphia. Some 102 piers and wharves lie adjacent to the 40-foot channel that has widths up to 2,300 feet for anchorage. Five facilities are specialized for handling petroleum or ore and are supported with storage for 1.3 million tons of petroleum. Many others are specialized to handle general and containerized cargo.

The Schuylkill River empties into the Delaware at Philadelphia and is extensively developed for commercial navigation for about 6 miles. The present project depth is 33 feet. Along the river are approximately 40 wharves, all except 2 of which are devoted entirely to petroleum products and are supported by petroleum storage for 1.1 million tons. The two exceptions provide access to a grain elevator with a 2.2 million bushel storage capacity.

The waterborne commerce of the Ports of Philadelphia, one-half of which is included in the statistics for the Delaware River - Bay to Philadelphia, with the other half included in the statistics for the Delaware River - Philadelphia to Trenton, grew very slowly over the 19 years ending in 1967, maintaining an average growth of only 1.2%. During the last 10 of those years, however, the average dropped to 0.5%. Commerce averaged 48,600,000 tons for the three years prior to 1968. The 1970 commerce was 52,200,000 tons.

The development programs for Philadelphia can be considered to be part of the Delaware River - Bay to Philadelphia.

Delaware River - Philadelphia to Trenton. Along the 30 miles of the Delaware River from Philadelphia to Trenton, there are 10 ports with 21 piers and wharves. Three wharves have depths of 42 feet and are used for handling iron ore, iron products and fuel oil, and abut the main river channel which is 40 feet deep. Two wharves with adjacent depths near 27 feet are designed for petroleum and coal handling and are supported by petroleum storage for 2,000 tons and coal storage for 200,000 tons. The remaining facilities have adjacent depths of less than 21 feet, and are generally used for handling petroleum products and are supported with petroleum storage for 125,000 tons.

If the present 300- to 400-foot channel widths are maintained, traffic control may have to be initiated because it is insufficient for two-way traffic. Bridges over the channel restrict horizontal clearance to a minimum of 240 feet; however, the channel terminates at Trenton at a bridge which restricts horizontal clearance to 60 feet and vertical clearance to 20 feet. The costs of past improvements to the Delaware River have averaged less than $1.00 per cubic yard dredged. However, spoil disposal may be a major problem for any future waterway improvement.

Waterborne commerce grew at an average annual rate of 5.9% over the 19-year period ending in 1967 and 4.8% over the last 10 years of that period. Commerce averaged 20,400,000 tons for the three years prior to 1968. Commerce in 1970 was 21,600,000 tons.

TABLE K-64
PORT SUMMARY - DELAWARE RIVER (PHILADELPHIA TO TRENTON)

PROJECTED RANGE OF WATERBORNE COMMERCE

	1970	1980	2000	2020
Millions of Tons	21.6	27-30	46-53	73-88

DEVELOPMENT PROGRAM

	1970	1980	2000	2020
Channel Depth (ft)	40	40	44	-
Improvement Cost ($Millions)	-	40 1/	100	-

1/ Channel widening cost.

RECREATIONAL BOATING

Boating can be a principal recreational activity in Area 15. There are dozens of 100- and 200-acre lakes now owned by the States, and for which State planning departments have constructed, or are planning to construct, recreational boating facilities. There are scores of privately-owned lakes suitable for boating. In addition, there are the rivers and Bay, although there is a conflict between commercial and recreational navigation in the lower 100 miles of the Delaware for both water and shore space.

Present public lakeside facilities include about 100 launching facilities. There are approximately 40 public boating facilities on Delaware Bay, including 2,500 permanent slips or moorages and 25 launching facilities. Between the Bay and Trenton, there are another 80 public boating facilities, including 3,500 permanent slips or moorages and 40 launching facilities.

Landlocked water bodies suitable for boating may not have enough recreators to spawn private development of facilities. Therefore, public funds may be required to provide launching facilities.

In many cases, boating development on the Delaware River may reasonably be expected by private enterprise. Public assistance may be required to establish exclusive areas for recreation and commercial navigation through zoning of the water surface.

TABLE K-65
SUMMARY - AREA 15

COMMERCIAL NAVIGATION

PROJECTED RANGE OF WATERBORNE COMMERCE

	1970	1980	2000	2020
Millions of Tons	120.6	137-203	204-266	303-438

INITIAL CAPITAL COSTS

	1980	2000	2020
Millions of Dollars	340+	450	-

RECREATIONAL BOATING

PROJECTED PLEASURE CRAFT

	1970	1980	2000	2020
Registered Craft*	100,000	110,000	137,000	167,000
Total Craft	173,000	216,000	320,000	535,000

*All motor boats.

INITIAL CAPITAL COSTS
(millions of dollars)

	1980	2000	2020
Berths	2.6	4.4	7.8
Launching Facilities	0.4	0.8	1.7

Area 16

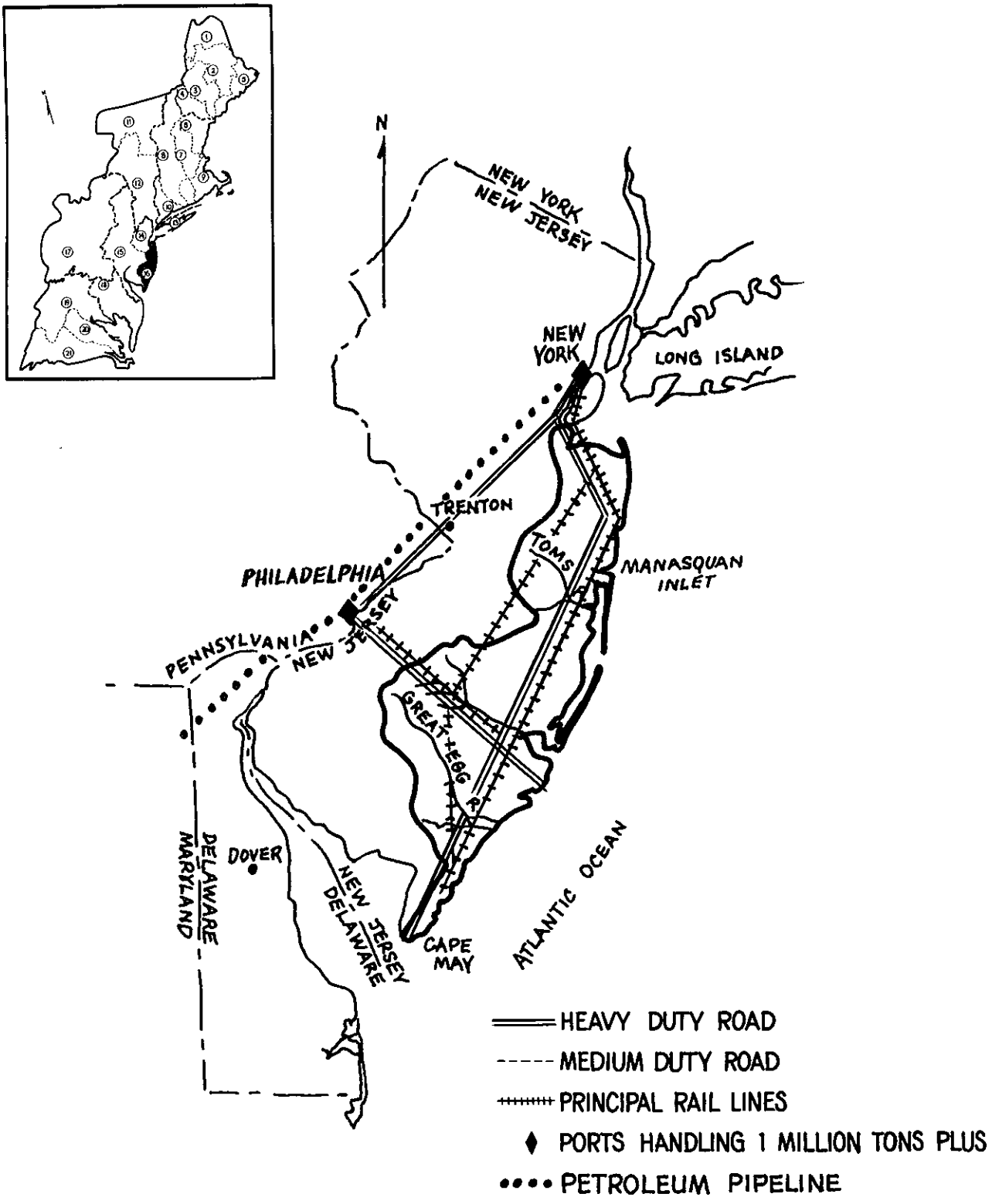


FIGURE K-27

AREA 16. COASTAL NEW JERSEY

Area 16 is among the highest in the Region in recreational boating activity, mainly because of extensive ocean and bay frontage, favorable climate, and accessibility from large metropolitan centers in adjacent areas. Overcrowding may become its most serious problem. Commercial activity is small and not expected to grow significantly.

Land Transportation

The map of Area 16 (Figure K-27) shows the competitive nature of the land transportation network to commercial navigation, and its strong support for recreational navigation.

Commercial navigation growth is expected to be small as the Area is just a few dozen miles from two of the largest and best developed ports in the Region, New York and Philadelphia, and well connected to them by the road and rail network.

The same network which severely limits development of commercial navigation, strongly encourages the development of recreational boating, because it places the recreational areas of Area 16 within a 2-hour drive of the major urban concentrations.

Waterways

Area 16 is a broad coastal plain unbroken by any major drainage basin, but fronted by an extensive barrier beach which has formed long, narrow, shallow bays for almost its entire 130-mile length. The bays are connected from Delaware Bay to the Atlantic Ocean at Manasquan Inlet by a continuous channel, 110-miles-long, which varies in depth from 1 to 12 feet, and which reflects the general depths of the bays themselves. Development of the waterway is inhibited by the difficulty of maintaining and stabilizing inlets through the barrier beach.

Vessel traffic consists of recreational craft, mostly of 3-foot draft or less, and fishing vessels, mostly of 6- to 7-foot draft.

Service Factors

Neither population concentrations or industrial activity significantly supports navigation. The population of 800,000 is so evenly distributed throughout the Area that there are only three cities which have populations exceeding 25,000. The sand and gravel production of the Area

can be adequately handled on the existing waterways. The volume of textiles, food, and sea-extracted magnesium compounds is not expected to increase enough by 2020 to exert pressure for navigation development.

COMMERCIAL NAVIGATION

Commodity Distribution

Area 16's waterborne commerce is evenly divided between fish, shellfish and petroleum products. Its commerce declined steadily over the 13-year period ending in 1967 at an annual rate of 2.5%, but at a rate of 2.8% over the last 5 of those years. Commerce in 1968 was slightly greater than 300,000 tons. Approximately one-fifth of the commerce is handled through Lower New York Bay, one-half at Manasquan, and the remainder at various harbors on the barrier bays.

Major Ports

New Jersey Intracoastal Waterway. The northern terminous of the waterway is in the Atlantic Ocean at Manasquan Inlet, 25 miles south of New York Bay. The existing project provides for a channel 12 feet deep and generally 100 feet wide from the Inlet, through Point Pleasant Canal to Delaware Bay above Cape May Point. The project length is about 117 miles. Except for the Cape May Harbor to Delaware Bay section, the waterway has never been constructed to project depth and has been deferred for restudy. Controlling depths vary greatly with a 1-foot depth between Great Egg Harbor and Townsend Inlets being the shallowest. Depths in other sections vary from 4 to 10.3 feet. A study currently underway may well recommend reduction in authorized depths in some portions of the waterway.

Included in this discussion are 11 coastal inlets which connect the waterway with the Atlantic Ocean. The inlets are Manasquan, Barnegat, Beach Haven, Little Egg, Brigantine, Absecon, Great Egg, Corson, Townsend, Hereford and Cold Spring. Improvements to these inlets are being studied for the combined purposes of navigation and beach erosion.

The reported waterborne commerce of the N. J. Intracoastal Waterway is the combined commerce of its many small harbors. Reported commerce has been extremely erratic, showing no trends. In the early-1950s it grew strongly, leveled off for a few years and then underwent an equally sharp drop in the early-1960s. Commerce recovered in the late-1960s and showed a growth rate of 1% which masked the fluctuations which occurred during the 13-year period ending in 1967. Commerce in 1970 was above 390,000 tons, almost all fish and shellfish and 25% greater than the commerce of 1967. Lower New York Bay commerce is not reflected in the following Table.

TABLE K-66
PORT SUMMARY - AREA 16 (NEW JERSEY INTRACOASTAL WATERWAY)

PROJECTED RANGE OF WATERBORNE COMMERCE

	1970	1980	2000	2020
Millions of Tons	0.3	0.3-0.5	0.5-0.9	1.0-1.5

DEVELOPMENT PROGRAM

	1970	1980	2000	2020
Channel Depth (ft)	1-10 1/	9-12	12	12+
Improvement Cost ($Millions)	-	10	10	5+

1/ Authorized depth is 12 feet.

The methodology has not been applied in arriving at the commerce projections shown in Table K-66 because of the extreme fluctuations of past commerce. An offshore terminal in Delaware Bay, for handling petroleum products, might significantly increase the commerce of this waterway. In other circumstances, fish and shellfish are expected to make up most of the commerce through 2020.

RECREATIONAL BOATING

Recreational boating is the most significant aspect of navigation in Area 16. While the number of registered craft in the Area is approximately 15,000, based on a strict per capita ownership according to population distribution, there are over 500 public boating facilities with about 22,000 permanent slips or moorages and 300 launching ramps. These facilities have generally been privately developed and support a strong boating tourist economy. Area 16 helps satisfy the recreational needs of Areas 14 and 15, as well as serving many transient boats from both within and outside the NAR.

Private development may tend to lag slightly behind the demand for recreational facilities. Expenditure of public funds on boating facilities may help accelerate meeting recreational needs, but this may not be in the best interest of any of the three planning objectives. The concern for a prime recreational experience, expressed generally under the Environmental Quality planning objective, might best be served by a slowing down of development rather than an acceleration of the development.

TABLE K-67
RECREATIONAL SUMMARY - AREA 16

RECREATIONAL BOATING

PROJECTED PLEASURE CRAFT

	1970	1980	2000	2020
Registered Craft*	14,800	18,400	31,000	39,000
Total Craft	22,200	27,000	50,000	66,000

*All motor boats

INITIAL CAPITAL COSTS
(millions of dollars)

	1980	2000	2020
Berths	5.2	18.4	11.6
Launching Facilities	1.2	6.0	4.2

TABLE K-68
SUMMARY - SUB-REGION D

COMMERCIAL NAVIGATION

PROJECTED RANGE OF WATERBORNE COMMERCE

	1970	1980	2000	2020
Millions of Tons	260.4	289.4-376.4	410.9-466.4	587.7-843.9

INITIAL CAPITAL COSTS

	1980	2000	2020
Millions of Dollars	449 1/	460 1/	5

1/ Excludes costs of alternative program of an offloading facility in N.Y.-N.J. Channels of $130 million in 1980 and $70 million in 2000.

RECREATIONAL BOATING

PROJECTED PLEASURE CRAFT

	1970	1980	2000	2020
Registered Craft*	204,800	228,400	297,000	368,000
Total Craft	330,200	431,000	540,000	1,031,000

*All motor boats.

INITIAL CAPITAL COSTS
(millions of dollars)

	1980	2000	2020
Berths	10.4	30.3	28.0
Launching Facilities	3.5	9.6	11.6
Crab Island Lock	4.2	-	-

SUB-REGION E

Sub-region E ranks next to last in commercial navigation activity when compared with the other NAR Sub-regions. However, its activity is significant because it is concentrated in one port, Baltimore. A large portion of the Nation's coal exports originate from this port, making it extremely important in maintaining competitive navigation development. Recreational boating is moderately high with high potential for expansion, providing that access problems are resolved.

COMMERCIAL NAVIGATION

Area 18 offers much greater potential for commercial navigation than Area 17, which is blocked by hydroelectric dams. Commercial navigation is significantly developed in Area 18, but further development will be inhibited by the extensive dredging which would be required to improve waterway access.

RECREATIONAL BOATING

While Areas 17 and 18 are more equal with respect to recreational boating potential, Area 18's potential is greater. Area 17 has extensive fresh water rivers although they are quite shallow. While fresh water boating opportunities are limited in Area 18, recreational boating needs are more than satisfied by one of the finest estuarine areas in the NAR - Chesapeake Bay.

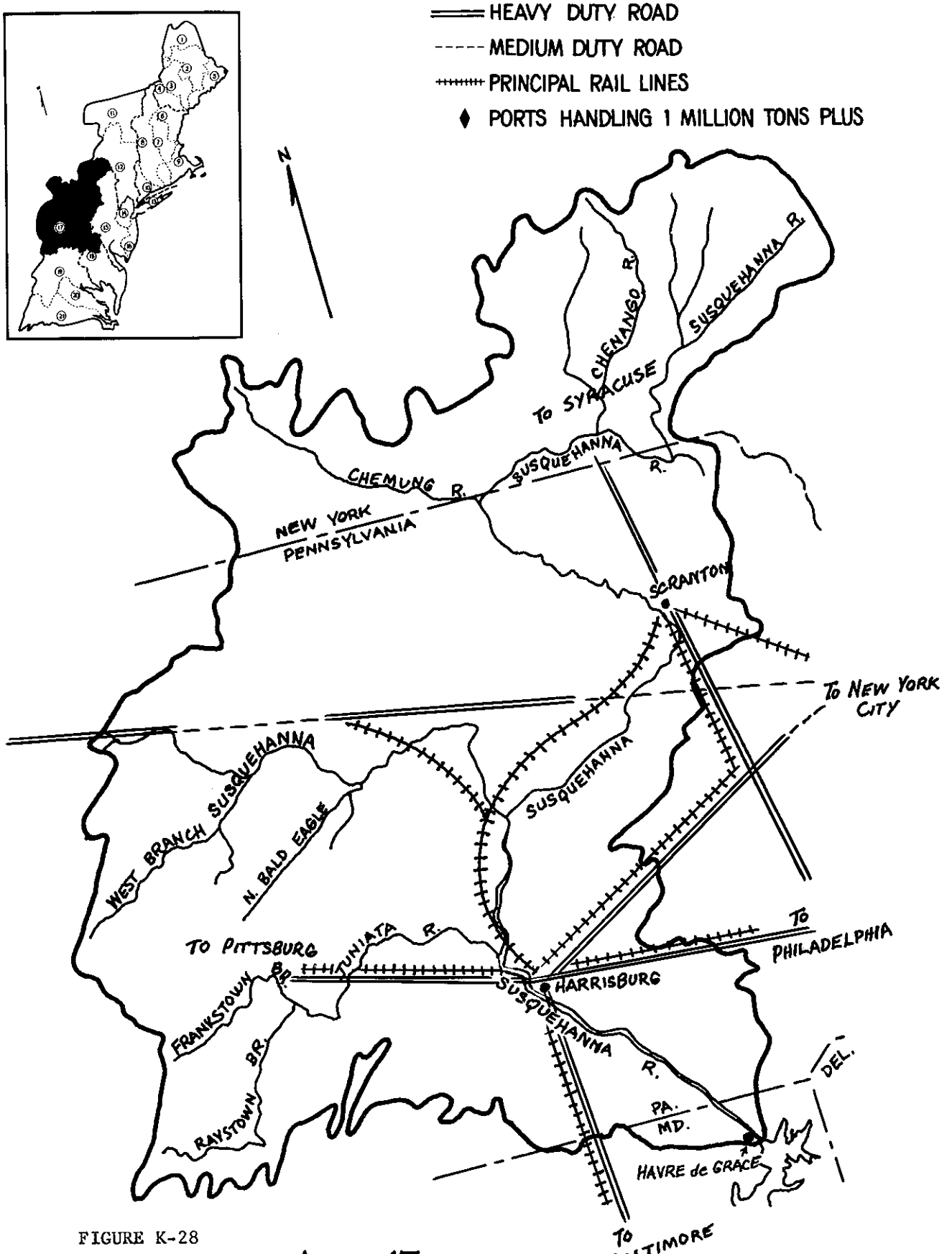


FIGURE K-28

Area 17

Commercial navigation activity is very small in Area 17, and is not expected to grow significantly. Recreational boating is moderately high and is constrained principally by access problems. Its growth can be expected to keep pace with the growth of the Area.

Land Transportation

The competition of highways and railroads, in conjunction with the development of hydroelectric power, has eliminated commercial navigation from the Area. Railroads are more highly developed than the road system because of the comparative ease of railroad construction through mountainous areas. (See Figure K-28).

Waterways

The Susquehanna River flows about 450 miles from its source at Lake Otsego in New York to its mouth at Havre de Grace, Md. Some improvements have been made in the central portion of the river to insure a depth of 5 feet for recreational craft. A hydroelectric dam blocks the river a few miles above its mouth. Above the dam, the river is up to 1 mile wide and ranges from 5 to 10 feet deep for over 100 miles. Below the dam, the inland portion of the river is closed up to four months due to ice.

Service Factors

Commodity demand is not favorable to navigation because it is generated by a population spread very thinly over the Area. Only three of the six cities with populations greater than 25,000 have city limits within 5 miles of the river.

The system of locks and dams inhibits navigation.

COMMERCIAL NAVIGATION

Major ports

Havre de Grace. The waterborne commerce reported for the Area is handled primarily through Havre de Grace. Its access channel is 15 feet deep in water that is naturally 8 feet deep between the port and water of the same depth in Chesapeake Bay.

Its commerce grew at an average rate of 7% for the 13 years ending in 1967, but this masks very substantial fluctuations due to construction requirements for sand and gravel. For example, commerce in 1963 amounted to 23,000 tons and in 1965, 28,000 tons. However, 164,000 tons were reported in 1964. Commerce in 1970 was 51,000 tons. Commerce in 2020 is expected to be less than 150,000 tons. No development plan is proposed as the existing waterway should be adequate to handle projected tonnage.

RECREATIONAL BOATING

Public boating facilities in the vicinity of Havre de Grace number about 17, including 1,400 permanent slips and moorages and 23 launching facilities. The location of these facilities suggest that they help satisfy boating demand generated in Area 18. A moderate to high amount of public funds may be required to meet future needs in the Pennsylvania and New York portions of the basin. Solely privately-financed facilities should be adequate to meet projected needs in Maryland.

TABLE K-69
SUMMARY - AREA 17

COMMERCIAL NAVIGATION

PROJECTED RANGE OF WATERBORNE COMMERCE

	1970	1980	2000	2020
Millions of Tons	0.05	0.06-0.10	0.08-0.12	0.10-0.15

DEVELOPMENT PROGRAM

No development program is considered likely.

RECREATIONAL BOATING

PROJECTED PLEASURE CRAFT

	1970	1980	2000	2020
Registered Craft*	32,200	35,000	45,000	56,000
Total Craft	68,000	84,000	136,000	212,000

*New York and Pennsylvania - all motor boats; Maryland - over 7.5 hp.

INITIAL CAPITAL COSTS
(millions of dollars)

	1980	2000	2020
Berths	0.7	2.6	2.7
Launching Facilities	0.3	1.0	1.5

Commercial navigation is a large and important activity in Area 18 because it supports large industrial water users, such as iron and steel manufacturers, and large coal exports. Recreational boating activity has an important place in helping to satisfy the recreational needs of the population of Area 18.

Land Transportation

Land transportation patterns on the western shore of the Bay are well developed to inland and other coastal centers with Baltimore as the hub because of its historically strategic location. In addition to numerous highways and railway lines, the area is also served by the Colonial Pipeline System which provides for a competitive bulk movement of petroleum products into the Area.

On the Bay's Eastern Shore land transportation systems have replaced historical patterns of heavy commercial navigation. Former centers of bustling maritime commerce are used for limited tonnages of special cargoes, supporting commercial fishing fleets and recreational fishermen with their markets and facilititates easy access to recreational areas from metropolitan centers. Key links in the complementary land transportation network are bridges at the mouth and mid-points of Chesapeake Bay (Figure K-29).

Chesapeake Bay is a well-protected inland estuary, open year round to maritime vessels, although some brief freeze overs have occurred during extended exceptionally low temperature periods. The less saline tributary waters experience more frequent ice closures. While much of the Bay has depths greater than 30 feet, there are extensive peripheral areas of 8 to 13 feet deep which may project several miles into the Bay. The major tributary rivers often have natural 9-foot depths a considerable distance inland from the Bay.

The 42-foot contour of the Bay is about 1 mile wide and extends 155 miles into the Bay from the Atlantic Ocean. It has been extended an additional 20 miles to Baltimore. The lower Bay is subject to shoaling over a 15-mile area and requires maintenance. Baltimore is connected to the Chesapeake and Delaware Canal by a waterway with authorized dimensions of 35 feet deep and 450 to 600 feet wide. Controlling depth at the present time is 27 feet, both in the connecting channel and the C&D Canal.

Area 18

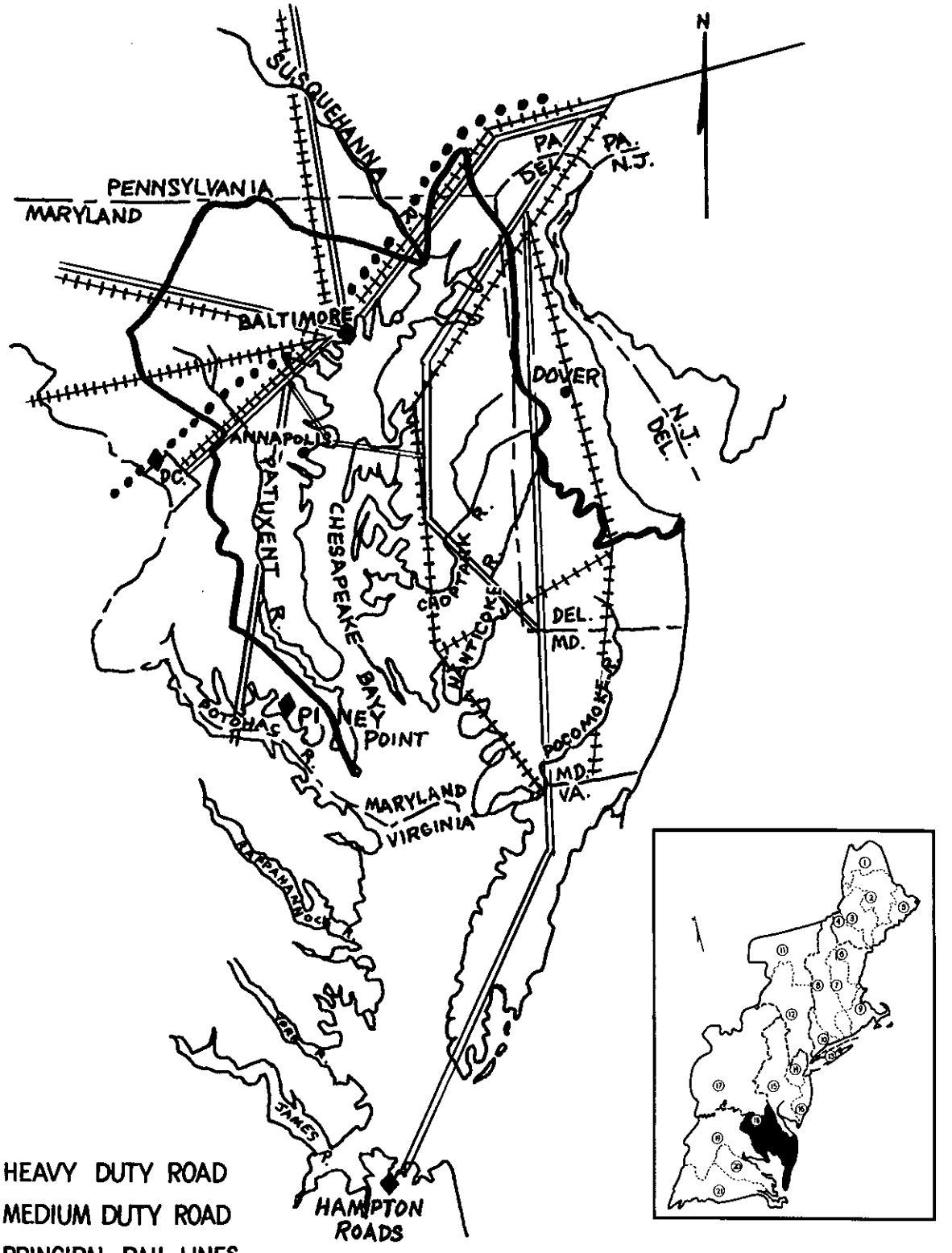


FIGURE K-29

Congress authorized the improvement of Baltimore Harbor generally to a depth of 50 feet in December of 1970. Major obstacles to deepening the waterway beyond this depth are the Chesapeake Bay Tunnel, at the mouth of the Bay and the Baltimore Harbor Tunnel in the upper harbor. The Chesapeake Bay Tunnel constrains channel width to 1,400 feet at its limiting depth of 60 feet. The Baltimore Harbor Tunnel limits channel depths to 50 feet for a distance of 1,900 feet in the Northwest Branch and Ferry Bar Channel reaches. However, this channel is upstream of all major facilities which could possibly require depths in excess of 50 feet, with the exception of the Humble Oil Terminal along the Northwest Branch. The difficulty of spoil disposal also must be considered. Appendix U, Coastal and Estuarine Areas, discusses implications of dredging in the coastal zone in some detail.

Service Factors

The Western Shore, primarily Baltimore Harbor and vicinity, has productive activity strongly favoring navigation development and a very favorable consumer market. Cement, coal, stone, paper, metals, machinery and sand and gravel are produced on the order of hundreds of thousands of tons annually. The population density approaches 12,000 per square mile in the vicinity of Baltimore, with a total population of over 2 million. Commodity demand on the Eastern Shore is generated by only 300,000 people spread so uniformly that there are only a few square miles with densities greater than 100 people. There is little industrial consumption to speak of. Attempts are currently being made to stimulate the economy of the Eastern Shore by inducing major industrial development which would be linked with or orientated toward waterborne commerce.

COMMERCIAL NAVIGATION

Commodity Distribution

Baltimore presently handles most of the waterborne commerce in Area 18. Accordingly, Table K-70 reflects the commodity distribution of that Port. The remaining commerce of Area 18 has fluctuated greatly between ports over the last 20 years. Twenty years ago, eight ports handled about 100,000 tons each; but today, in response to land transportation development, population movement and industrial growth, some of those ports have declined to less than 30,000 tons, while some now report commerce of about 400,000 tons.

TABLE K-70
COMMODITY DISTRIBUTION - AREA 18

		1955		1965		1968	
Total - 1000's of tons		45,800	100%	44,300	100%	42,500	100%
Coal	F/E	9,862	22%	9,922	22%	10,486	25%
Iron Ore	F/I	10,356	23%	11,526	26%	10,374	24%
Residual Fuel Oil	F/I	2,914	6%	4,268	10%	4,421	10%
Iron	F/IE	1,752	4%	2,000	5%	2,500	5%
Distillate Fuel Oil	D/I	2,354	5%	2,350	5%	1,995	5%
Gasoline	D/I	2,843	6%	2,254	5%	1,995	5%
Grains	F/E	2,100	5%	1,100	2%	900	2%
Chemicals	LF/I	670	1%	860	1%	900	2%
Other Ores	F/I	2,500	5%	1,600	4%	800	2%
Sugar	F/I	530	1%	720	1%	800	2%
Oils/asphalt, etc.	DL/I	200		950	1%	700	1%
Crude Petroleum	F/I	3,019	7%	671	1%	637	1%
Jet Fuel/Kerosene	D/I	429	1%	338		405	1%

L = Local, F = Foreign, D = Domestic, I = Import, E = Export.

Major Ports

Baltimore. The Port of Baltimore is similar to a long stemmed "Y" in shape. A vehicular tunnel crosses under the harbor just seaward of the fork at a depth of 55 feet, but maximum waterway depth is limited to 50 feet by tunnel cover requirements. There are more than 60 facilities along the south side of the stem and they are supported by covered storage (1 million square feet) and petroleum storage (almost 1 million tons). The north side of the stem includes an offshoot channel 42 feet deep, with more than 70 facilities specialized for handling bulk commodities and effecting repairs and supported by petroleum storage (1.1 million tons). The Northwest Branch has authorized depths from 49 to 40 feet and provides access to 15 facilities served by rail lines and specialized to handle ores and grain. The south fork varies in depth from 42 to 25 feet and provides access to 77 facilities specialized to handle general cargo, supported by covered storage (1 million square feet) and serviced by rail lines.

Waterborne commerce grew at an annual average rate of 0.6% during the 19 years ending in 1967 but at the even slower rate of 0.3% over the last 10 of those years. Commerce averaged 42,960,000 tons for the three years prior to 1968. Commerce in 1970 totalled 51,100,000 tons. The projected commerce has an annual growth rate ranging from 1.0% to 2.5%.

TABLE K-71
PORT SUMMARY - BALTIMORE

PROJECTED RANGE OF WATERBORNE COMMERCE

	1970	1980	2000	2020
Millions of Tons	51.1	56.2-65.5	69.0-107.5	84.0-176.0

DEVELOPMENT PROGRAM

	1970	1980	2000	2020
Channel Depth (ft)	42 1/	50	60 2/	-
Improvement Cost ($Millions)	-	120	150	-

1/ Authorized depth is 50 feet.
2/ Alternative program - Offloading facility, cost of which has not been determined.

Wicomico River. The Wicomico River is located in the southeastern portion of Chesapeake Bay on the Delmarva Peninsula. It is navigable over a 14-foot deep channel 25 miles to Salisbury, which has access to the peninsula's railroad network and is a crossroads of the peninsula's major highways.

Waterborne commerce increased at an average annual rate of 4% during the 19-year period ending in 1967, but this accelerated to 4.5% over the last 10 of those years. Commerce in 1970 was 800,000 tons. Prospective commerce in excess of 1,600,000 tons is not expected through 2020. The existing project is considered adequate to handle the expected tonnage. Therefore, no development program is proposed for the Wicomico River.

TABLE K-72
PORT SUMMARY - WICOMICO RIVER

PROJECTED RANGE OF WATERBORNE COMMERCE

	1970	1980	2000	2020
Millions of Tons	0.8	1.0-1.2	1.6	1.6

DEVELOPMENT PROGRAM

No development program is considered likely.

Choptank River. The cities of Denton, Cambridge and Easton are ports served by the Choptank River or its tributaries on the peninsula. The Choptank is navigable for over 50 miles with natural depths exceeding 12 feet in all but 8 or 9 miles of waterway extensions or port access channels. There is an authorized project for the river which provides for an 8 to 12 foot channel to the head of navigation at Greensboro. The Tred Avon project will provide for a 12-foot channel to Easton when completed. Also, the State has dredged a 25-foot channel to the port of Cambridge.

Waterborne commerce was static on the average over the 19-year period ending in 1967 but was increasing at an average annual rate of 3% over the last 10 of those years. Commerce averaged 520,000 tons for the three years prior to 1968. Commerce in 1970 totalled 620,000 tons; mostly petroleum products, fertilizers, construction materials, fish and shellfish, and slag.

The present projects are expected to be able to handle prospective commerce which is not expected to exceed 1.3 million tons. Therefore, no development program is considered likely. However, consideration should be given to Federal takeover and maintenance of the State project to the port at Cambridge.

TABLE K-73
PORT SUMMARY - CHOPTANK RIVER

PROJECTED RANGE OF WATERBORNE COMMERCE

	1970	1980	2000	2020
Millions of tons	0.6	0.7-0.8	1.2-1.3	1.3

DEVELOPMENT PROGRAM

No development program is considered likely. However, consideration should be given to Federal takeover of the State's project at Cambridge Harbor.

Nanticoke River. The Nanticoke River and its tributaries serve Tyaskin, Bivalve, Nanticoke, Blade and Seaford on the peninsula. There are five Federal projects in the basin. The Nanticoke River project provides for a 12-foot deep channel for a 40-mile distance to Seaford, Md., and for a 6-foot channel in the Northwest Fork for a distance of 16 miles. The Broad Creek project extends from the Nanticoke River at mile 34 over 8 miles to Laurel, Md. It provides a channel 8 feet deep. There are also three projects providing access from the river to the Eastern

Shore; at Nanticoke, Bivalve and Tyaskin. The first two projects provide a 7-foot depth, while a 9-foot depth is provided to Tyaskin. These three harbors report fish and occasionally petroleum and are used for recreation.

Waterborne commerce has grown strongly and steadily over the 19-year period ending in 1967, averaging 4.6% annually. Commerce averaged 383,000 tons for the three years prior to 1968. The 1970 commerce was 488,000 tons; three-fourths petroleum products, and the remainder pulpwood, grains, or waste. Prospective commerce is not expected to exceed 1.3 million tons by 2020.

The existing Federal projects are expected to adequately meet the needs of the prospective commerce. Therefore, no development program is proposed for the Nanticoke River.

TABLE K-74
PORT SUMMARY - NANTICOKE RIVER

PROJECTED RANGE OF WATERBORNE COMMERCE

	1970	1980	2000	2020
Millions of Tons	0.5	0.6-0.8	0.8-1.0	1.0-1.3

DEVELOPMENT PROGRAM

No development program is considered likely.

Pocomoke River. The Pocomoke River empties into Chesapeake Bay near its mouth. It has natural depths of 9 feet for 26 miles which have been extended an additional 4 miles to the city of Snow Hill, which is a lumbering center. The river mouth is exceptionally unstable, requiring maintenance dredging every two or three years. An authorized 11-foot Federal project has recently been placed in the inactive category.

Waterborne commerce grew at an average annual rate of nearly 5% during the 19 years ending in 1967 but over the last 10 of those years the average increase was only 3.3%. Commerce averaged 115,000 tons for the three years prior to 1968. The 1970 commerce was 171,000 tons; two-thirds forest products and one-fifth petroleum products. Prospective commerce is not expected to exceed 700,000 tons by the year 2020.

Patuxent River. The Patuxent is located just south of Baltimore and navigable for 50 miles with natural depths exceeding 10 feet. A number of tributary creeks near its mouth have been developed for recreational boating and have access channels of 6 feet. A U. S. Naval Air Base located along its shores is the major commercial user of the waterway. Jet fuel alone exceeded 50% of the 1970 reported tonnage.

TABLE K-75
PORT SUMMARY - POCOMOKE RIVER

PROJECTED RANGE OF WATERBORNE COMMERCE

	1970	1980	2000	2020
Millions of Tons	0.2	0.2-0.3	0.4-0.5	0.6-0.7

DEVELOPMENT PROGRAM

No development program is considered likely.

TABLE K-76
PORT SUMMARY - PATUXENT RIVER

PROJECTED RANGE OF WATERBORNE COMMERCE

	1970	1980	2000	2020
Millions of Tons	0.1	Not projected.		

DEVELOPMENT PROGRAM

No development program appears likely.

Commerce grew at an average annual rate of 7.4% during the 19 years ending in 1967 but slowed to 4.9% in the last 10 of those years. Commerce averaged 150,000 tons for the three years prior to 1968. The 1970 commerce was 138,000 tons, mostly jet fuel and other petroleum commerce. Commerce has not been projected due to the uncertainty in needs for the Naval base. However, with or without the base, natural depths should be sufficient for all prospective commerce.

RECREATIONAL BOATING

Chesapeake Bay is one of the finest areas for recreational boating in the North Atlantic Region, primarily because of the scores of rivers flowing into it which provide sheltered areas for launching ramps and marinas and also provide access to the Bay's open reaches.

Many of the creeks and rivers which support boating, regularly report commercial commerce, primarily fish, shellfish, construction materials or petroleum. By the same token, many commercial waterways have significant recreational boating. Nanticoke is the best example, with almost 100 permanent berths or moorages and three launching ramps.

The mainland coastal plain has 214 public boating facilities with about 14,000 permanent slips or moorages and 133 launching facilities.

The peninsula has 125 public boating facilities with almost 5,000 permanent slips or moorages and 93 launching facilities.

Private funds have provided most of the facilities existing now, and can be expected to satisfy the demand of the future with a minimum of public funds.

TABLE K-77
SUMMARY - AREA 18

COMMERCIAL NAVIGATION

PROJECTED RANGE OF WATERBORNE COMMERCE

	1970	1980	2000	2020
Millions of Tons	53.3	58.7-68.6	73.1-111.9	88.5-180.9

INITIAL CAPITAL COSTS

	1980	2000	2020
Millions of Dollars	120	150	-

Costs shown are for channel improvement. Cost of the alternative program of off loading facility for Baltimore Harbor has not been estimated.

RECREATIONAL BOATING

PROJECTED PLEASURE CRAFT

	1970	1980	2000	2020
Registered Craft*	53,000	59,000	72,000	91,000
Total Craft	93,000	113,000	209,000	276,000

*Delaware - all motor boats; Maryland - over 7.5 hp; Virginia - 10 or more hp.

INITIAL CAPITAL COSTS
(millions of dollars)

	1980	2000	2020
Berths	11.1	8.9	12.6
Launching Facilities	0.9	4.7	3.3

TABLE K-78
SUMMARY - SUB-REGION E

COMMERCIAL NAVIGATION

PROJECTED RANGE OF WATERBORNE COMMERCE

	1970	1980	2000	2020
Millions of Tons	53.4	58.8-65.6	69.1-107.6	84.1-176.2

INITIAL CAPITAL COSTS 1/

	1980	2000	2020
Millions of Dollars	120	150	-

1/ Costs shown are for channel improvements. Cost of alternative program of offloading facility for Baltimore Harbor has not been estimated.

RECREATIONAL BOATING

PROJECTED PLEASURE CRAFT

	1970	1980	2000	2020
Registered Craft*	85,200	94,000	117,000	147,000
Total Craft	161,000	197,000	345,000	488,000

*Pennsylvania & New Jersey - all motor boats; Maryland - over 7.5 hp.

INITIAL CAPITAL COSTS
(millions of dollars)

	1980	2000	2020
Berths	11.8	11.5	15.3
Launching Facilities	1.2	5.7	4.8

SUB-REGION F

Sub-region F ranks fourth among the NAR Sub-regions in terms of commercial navigation activity, which is significant in that more than half of the commerce consists of major coal exports from Hampton Roads. Despite some physical constraints, the future of this activity is strong. Recreational boating is moderate and expected to keep pace with the Sub-region's economic growth.

COMMERCIAL NAVIGATION

The James and York Estuaries in Areas 21 and 20, respectively, offer the best potential for continued navigation development because of their available depths and existing facilities.

RECREATIONAL BOATING

The Areas are about equal in their potential for recreational boating, which is moderately high. Each Area in Sub-region F has extensive Bay frontage, but generally poor accessibility and remote location with respect to population centers.

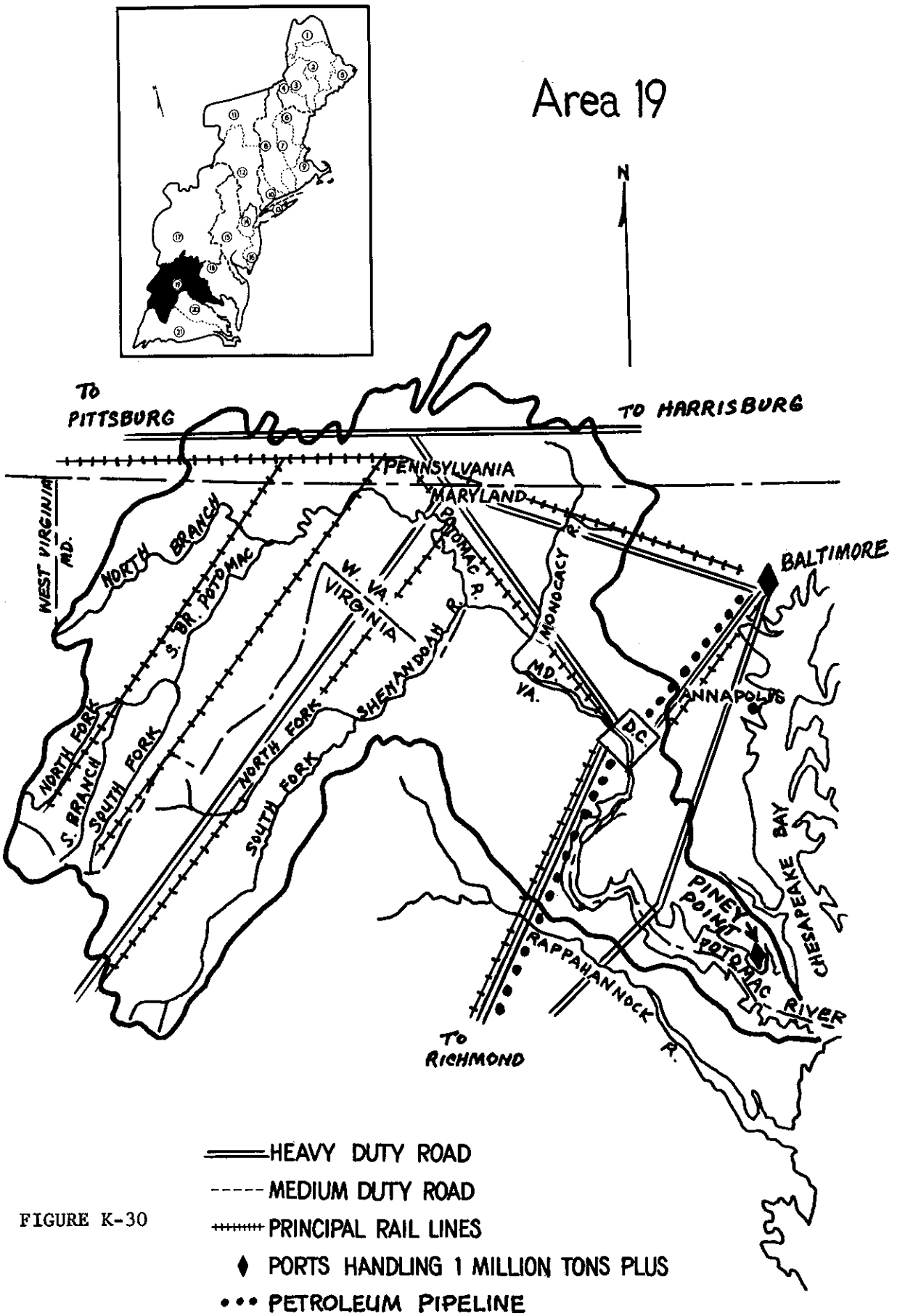

Area 19
N
TO PITTSBURG
TO HARRISBURG
PENNSYLVANIA
MARYLAND
WEST VIRGINIA
MD.
NORTH BRANCH
S. BR. POTOMAC
W. VA.
VIRGINIA
POTOMAC R.
MONOCACY R.
BALTIMORE
SHENANDOAH R.
MD.
VA.
D.C.
ANNAPOLIS
NORTH FORK
S. BRANCH
SOUTH FORK
NORTH FORK
SOUTH FORK
BAY
CHESAPEAKE
PINEY POINT
POTOMAC RIVER
RAPPAHANNOCK R.
TO RICHMOND
HEAVY DUTY ROAD
MEDIUM DUTY ROAD
PRINCIPAL RAIL LINES
PORTS HANDLING 1 MILLION TONS PLUS
PETROLEUM PIPELINE

FIGURE K-30

Commercial navigation activity is limited. Recreational boating is expected to keep pace with the Area's general development, although overcrowding problems may become significant near the end of the planning period.

Land Transportation

Land transportation strongly competes with commercial navigation and can be expected to inhibit its development. The Chesapeake and Ohio Canal, which connected the Nation's Capital and Cumberland, Md., and transported over 900,000 tons in 1876, was closed in 1924 due to competition from land transportation. The map of Area 19 (Figure K-30) shows the existing land transportation pattern. It can be thought of as an extension of the radial system of Baltimore. Land transportation, especially the railroad, is particularly competitive because of the lack of development in the vicinity of the port facilities. In addition, Washington, D. C., is one of the cities that are served by the Colonial Pipeline System, which tends to compete with waterborne petroleum.

Waterways

Most of the water surface of Area 19 is formed by the Potomac River and its tributaries, although there are a few lakes in the mountain valleys deep inland. Most of the recreational and all of the commercial navigation takes place on the Potomac. Above Washington, D. C., the river passes over falls and through mountains and tends to be shallow and narrow. The river is approximately 20 feet deep in the vicinity of Washington, D. C., and gets progressively deeper towards the mouth where depths between 39 and 92 feet can be found. The river varies in width from 1,000 feet at the head of tide near Washington, D. C., to about 6 miles at the mouth where it enters Chesapeake Bay.

Service Factors

Commodity demand is generated by 3.6 million people, more than half of whom live within 30 miles of the Potomac River. Population density approaches 12,000 per square mile in the vicinity of Washington, D. C.

Stone, sand and gravel are produced in volume but only 14 million tons are shipped by water routes. Agriculture, chemicals and metal industries are potential users of navigation, but historically, have not used ship transport. There is a significant consumption of petroleum products.

COMMERCIAL NAVIGATION

Commodity Distribution

Table K-79 clearly shows the importance of the local sand and gravel distribution and petroleum products. Most of the petroleum is delivered to Piney Point by bulk vessels and then transshipped to barges for redistribution. The tonnage transshipped has been estimated and eliminated from reported waterborne statistics for the river.

TABLE K-79
COMMODITY DISTRIBUTION - AREA 19

		1955		1965		1968	
Total - in 1000's of tons		3,027	100%	3,802	100%	3,079	100%
Sand and Gravel	L	1,237	41%	2,095	55%	1,476	48%
Residual Fuel Oil	F/I	464	15%	700	18%	991	32%
Distillate Fuel Oil	D/I	287	9%	312	8%	199	6%
Jet Fuel/Kerosene	D/I	30		210	6%	236	8%
Paper	F/I	76		136	4%	155	5%
Gasoline	D/I	867	29%	336	9%	76	2%
Fish/Shellfish	L	35		47		46	1%
Crude Petroleum	F/I					213	7%

L = Local, F = Foreign, D = Domestic, I = Import.

Major Ports

Potomac River. The Potomac carries a large sediment load and is subject to shoaling in many places. Washington, D. C., and Piney Point, Md., are the major ports on the river. Where necessary, the natural channel has been improved to provide a waterway to Washington, D. C., that is 24 feet deep and 200 feet wide. The proximity of Baltimore and a general lack of facility-development at Washington, D. C., are dampening factors on navigation development of the Potomac River, which are only partially offset by the deep-draft petroleum handling facility at Piney Point.

Waterborne commerce grew at an average annual rate of 2% over the 19-year period ending in 1967 but, slowed to 0.8% during the last 10 of those years. Commerce averaged about 3,600,000 tons for the three years prior to 1968. The 1968 commerce was 3,100,000 tons.

TABLE K-80
PORT SUMMARY - AREA 19 (POTOMAC RIVER)

PROJECTED RANGE OF WATERBORNE COMMERCE

	1970	1980	2000	2020
Millions of Tons	3.5	3.6-3.9	4.4-5.8	5.9-9.1

DEVELOPMENT PROGRAM

	1970	1980	2000	2020
Depth (ft)	25	50 1/	65 1/	-
Improvement Cost ($Million)	-	Cost not Estimated.		-

1/ Development program calls for an offshore terminal in the lower Potomac River or in Chesapeake Bay with entrance channels to depths shown. This would require relocation of the Chesapeake Bay bridge-tunnel.

RECREATIONAL BOATING

The Potomac River has a highly irregular shoreline often interrupted by creeks and embayments. The surrounding area is rich with historical sites, many with readily available access from the river. The population of Washington, D. C., generates a great demand for permanent boating facilities and the nature of the area requires a large number of public launching sites. Along the banks of the Potomac between Washington, D. C.,and Chesapeake Bay are 95 boating facilities with about 5,600 permanent slips or moorages and 68 public launching facilities.

Demand for facilities in the lower Potomac can be expected to be met by private enterprise, but facilities in the upper part of Area 19, which may not receive intensive use, might best be developed by public funds. Launching facilities may be particularly important in view of the large number of annual summer tourists.

TABLE K-81
RECREATIONAL SUMMARY - AREA 19

RECREATIONAL BOATING

PROJECTED PLEASURE CRAFT

	1970	1980	2000	2020
Registered Craft*	45,700	55,200	79,900	107,500
Total Craft	83,500	94,000	163,000	220,000

*Maryland - over 7.5 hp.; West Virginia - over 5 hp.;
Virginia - 10 or more hp.; District of Columbia - over 10 hp.

INITIAL CAPITAL COSTS
(millions of dollars)

	1980	2000	2020
Berths	13.7	16.5	18.5
Launching Facilities	0.2	1.4	1.1

Commercial navigation is not expected to become a significant activity in Area 20 because of physical constraints and the lack of good land transportation. Recreational boating may increase to moderate levels with the improvement of public access and facilities.

Land Transportation

The map of Area 20 (Figure K-31) illustrates that land transportion cannot support or compete with navigation for the simple reason that it is almost undeveloped. Improvement of the land transportation system may result in some reduced commercial traffic because of the Area's proximity to major ports and increased recreational boating because of its proximity to large urban concentrations. However, the major portion of the commercial traffic is crude oil imports, which is not expected to be affected by land transportation improvements due to the large fixed plant investment in the Yorktown refinery.

Waterways

The estuarine portions of the rivers in Area 20 are exceptionally favorable to navigation as they tend to be deep and wide. However, the remaining portions tend to be unfavorable because they shoal rapidly and become very sinuous and narrow. Near-shore depths of the Chesapeake Bay range between 8 and 20 feet. This compares with estuarine depths of between 30 and 70 feet.

There are no known restrictions to deepening the rivers of Area 20, although the water table around the York River is severely depressed. Deepening it significantly beyond natural depths raises the possibility of ground water contamination. The York River, above the fork at West Point, is characterized by extensive marshland which is distinctly unfavorable to navigation.

Reported vessel traffic has remained quite constant in total numbers during a period in which commerce grew strongly indicating a trend towards larger vessels. Bulk vessels reflect activity at the Yorktown refinery which is responsible for well over half of the waterborne commerce reported in the Area. The tide range does not aid vessel movements because it rarely exceeds 2 feet.

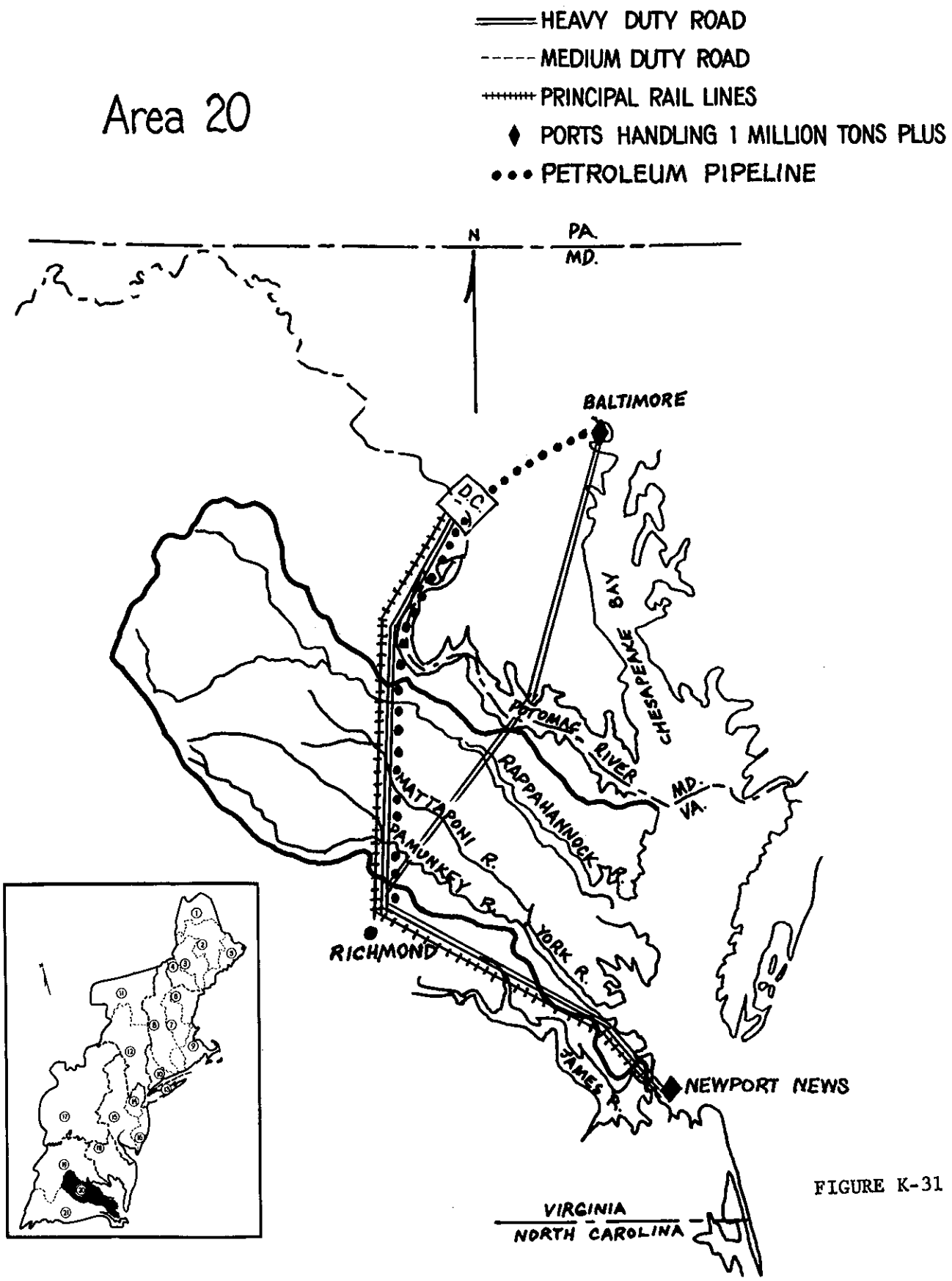

Area 20
HEAVY DUTY ROAD
MEDIUM DUTY ROAD
PRINCIPAL RAIL LINES
PORTS HANDLING 1 MILLION TONS PLUS
PETROLEUM PIPELINE
N
PA.
MD.
BALTIMORE
D.C.
CHESAPEAKE BAY
POTOMAC RIVER
MD.
VA.
RAPPAHANNOCK R.
MATTAPONI R.
PAMUNKEY R.
YORK R.
RICHMOND
JAMES R.
NEWPORT NEWS
VIRGINIA
NORTH CAROLINA

FIGURE K-31

Service Factors

Industrial activity of petroleum refining is a major factor of the commerce reported for Area 20. Commerce also includes sand, gravel, grain, stone and forest products, all of which have been occasionally reported in commerce statistics, but only petroleum products are consistently transported by water.

There is no local market large enough to support diversified navigation. Fredericksburg, the largest city in the Area, had a population of about 10,000 in 1960, and virtually all the other settlements had populations of 2,000 or less.

COMMERCIAL NAVIGATION

Commodity Distribution

Table K-82 shows the enormous percentage that petroleum constitutes in the commerce of Area 20. Crude petroleum, which is considered to be insensitive to competition from nearby areas, has accounted for more than half the increase in tonnage in the 1955-1968 period.

TABLE K-82
COMMODITY DISTRIBUTION - AREA 20

		1955		1965		1968	
Total - 1000's of tons		892	100%	4,500	100%	5,600	100%
Crude Petroleum	F/I			1,696	38%	2,364	42%
Gasoline	D/E	236	26%	1,223	27%	1,441	26%
Distillate Fuel Oil	D/E	36	4%	706	16%	897	16%
Residual Fuel Oil	DF/I	24	3%	189	4%	292	5%
Forest Products	D/I	236	26%	260	6%	264	5%
Jet Fuel/Kerosene	D/I	24	3%	164	4%	123	2%
Fish	L	100	11%	33	1%	34	
Chemicals	D/I			58	1%	95	2%
Grains	D/E	16	2%	35	1%	30	1%
Sand and Gravel	L	55	6%				

F = Foreign, D = Domestic, L = Local, I = Import, E = Export.

Major Ports

York River. The York River has an estuary 35 miles long with a Federal project providing for a channel 22 feet deep and 400 feet wide as far as Yorktown. The head of the estuary is formed by the confluence of

the Pamunkey and Mattaponi Rivers which have been improved for shallow-draft navigation. The Pamunkey River project provides a 7-foot depth from the mouth upstream about 47 miles, thence a 5-foot channel to mile 51.6, all with a width of 100 feet. The Mattaponi project provides a 16-foot entrance channel, a 9-foot channel from the mouth to mile 28 and thence 7 feet deep an additional 13 miles.

Waterborne commerce grew at an annual average of 13% over the 19-year period ending in 1967, but has been rather static during the last 10 of those years. Commerce averaged 4,600,000 tons for the three years prior to 1968. The 1970 commerce was 4,700,000 tons on the York River, 5,000 tons on the Mattaponi River, and 54,000 on the Pamunkey River.

TABLE K-83
PORT SUMMARY - YORK RIVER

PROJECTED WATERBORNE COMMERCE

	1970	1980	2000	2020
Millions of Tons	4.8	5.7-8.0	8.0-13.0	10.0-21.5

DEVELOPMENT PROGRAM

	1970	1980	2000	2020
Channel Depth (ft)	22 1/	50	-	-
Improvement Cost ($Millions)	-	24	-	-

1/ Authorized project is 22 feet. However, there are natural depths of about 40 feet along most of the channel. Therefore, deepening is relatively inexpensive.

Rappahannock River. The Rappahannock River has a project depth of 12 feet as far as Fredericksburg, 107 miles upstream. Maintenance is required above the 75-mile point and through shoal areas at about the 40-mile point. Depths up to 50 feet are available for a few miles into the mouth of the estuary. Most of the river's ports and harbors are located within the first 40 miles, including Carters Creek, Greenvale Creek, Hoskins Creek, Totuskey Creek, Urbana Creek and 7 others, all with Federal projects. There are 16 towns with total 1960 populations of 20,000. Generally, the creeks have been developed for fishing and recreation fleets.

Commerce declined at an average annual rate of 1.6% over the 19-year period ending in 1967, however the decline accelerated to 7% in the last 10 of those years. Commerce averaged 219,000 tons for the

three years prior to 1968. The 1970 commerce was 223,000 tons for the Rappahannock River, and nearly 64,000 tons to the river's ports and harbors in the first 40 miles. Commerce is expected to experience little growth in the planning period.

TABLE K-84
PORT SUMMARY - RAPPAHANNOCK RIVER

PROJECTED RANGE OF WATERBORNE COMMERCE

	1970	1980	2000	2020
Millions of Tons	0.3	0.3	0.3	0.3-0.4

DEVELOPMENT PROGRAM

No development program is considered likely.

RECREATIONAL BOATING

Open non-urbanized spaces, the relative calm waters of the estuaries and Chesapeake Bay, and rivers navigable for over 100 miles, make recreational boating particularly enjoyable in Area 20. There are some 122 boating facilities along the coastal and river shorelines, with about 2,500 permanent slips or moorages and 62 launching facilities.

Improvements most likely to be needed in this Area are launching sites and access to them which will undoubtedly require public funding.

TABLE K-85
SUMMARY - AREA 20

COMMERCIAL NAVIGATION

PROJECTED RANGE OF WATERBORNE COMMERCE

	1970	1980	2000	2020
Millions of Tons	5.1	6.0-8.3	8.3-13.3	10.3-21.9

INITIAL CAPITAL COSTS

	1980	2000	2020
Millions of Dollars	24	-	-

RECREATIONAL BOATING

PROJECTED PLEASURE CRAFT

	1970	1980	2000	2020
Registered Craft*	5,400	6,000	8,100	11,600
Total Craft	8,400	10,200	15,300	21,200

*10 or more hp.

INITIAL CAPITAL COSTS
(millions of dollars)

	1980	2000	2020
Berths	0.4	1.4	2.4
Launching Facilities	0.4	1.0	1.2

Commercial navigation is a very large and important activity, dominated by coal exports, in Area 21. It is expected to grow despite some physical development constraints. Recreational boating is moderate and is expected to develop with the Area, although it faces increasing conflicts with commercial navigation and localized overcrowding problems.

Land Transportation

Land transportation complements navigation in the James River Estuary area from Richmond to Hampton Roads. At Richmond, navigation is somewhat limited due to restrictive channel dimensions and channel curvature. However, commerce at Richmond terminals is ably and efficiently handled and can be transferred to trucks and railroads operating over high-speed, heavy-duty highways and rail lines radiating to all points of the compass. The Hampton Roads port area, Newport News and Norfolk, is a commercial navigation center well served by excellent railroad, storage, shipping, shipbuilding and repair, and freight forwarding services and facilities. (See Figure K-32).

Waterways

The confluence of the James and Appomattox Rivers forms the head of the James Estuary. Both of the rivers are very narrow, seldom wider than 200 or 300 feet, and are generally shallower than 10 feet and very winding. The estuary is generally about 30 feet deep, and several miles wide in many places.

Development of the estuary may be inhibited by vehicular tunnels which cross under the access channels to Hampton Roads. The harbor tunnel between Newport News and Norfolk presently limits channel depth to 57 feet. The Chesapeake Bay Bridge-Tunnel which connects Norfolk to the Delmarva Peninsula, effectively limits the channel depth to 55 feet, although there is a section 60 feet below mean low water. The estuary is generally ice free and experiences a tide range of less than three feet.

Reported vessel traffic suggests that all channels were adequate for commerce navigation as of 1968. While past channel improvements may not have significantly stimulated the growth of waterborne commerce, there is no doubt that industry has taken full advantage of the reduced transportation costs offered by the larger vessels. River traffic appears to be becoming increasingly barge-oriented.

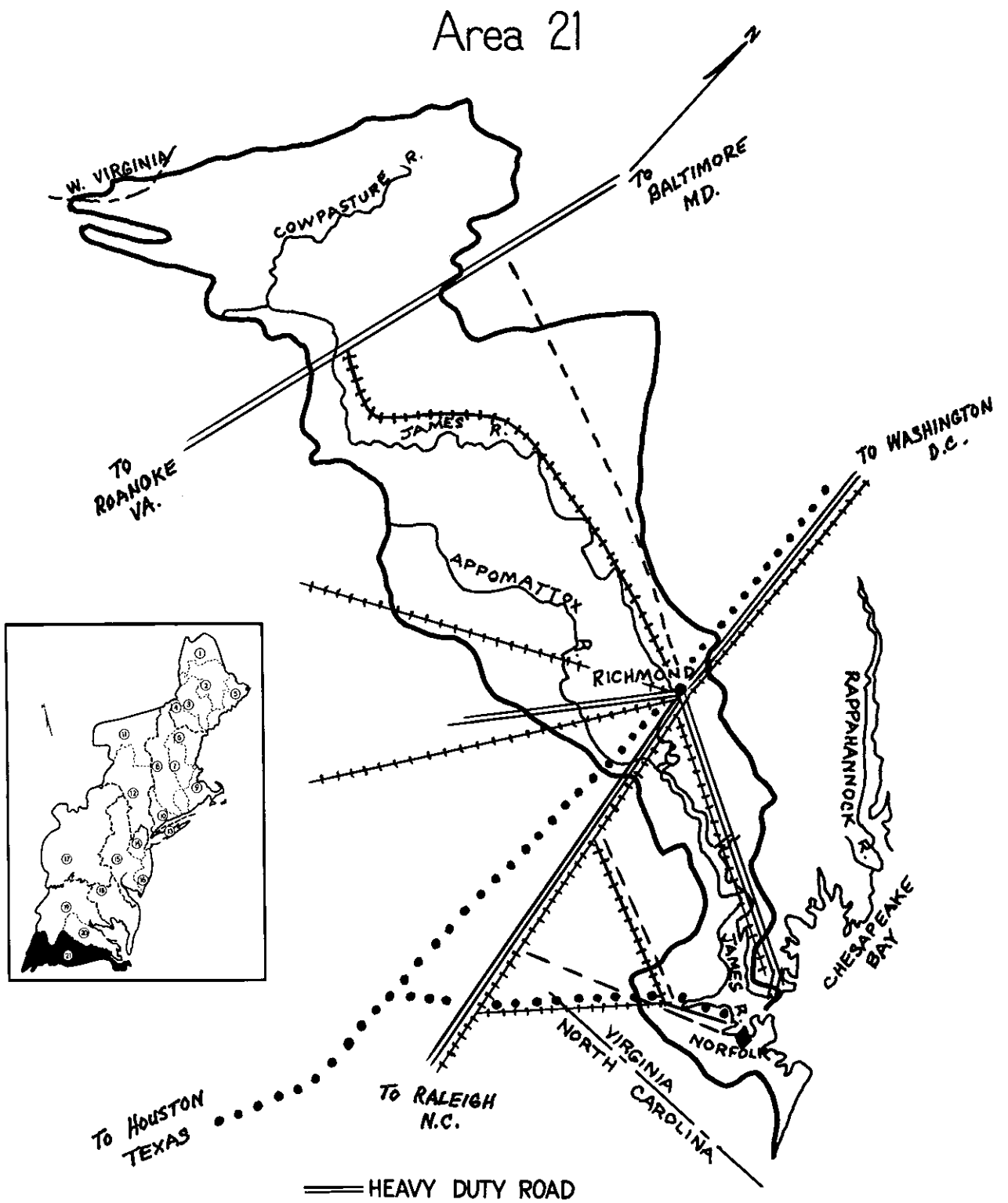

Area 21
W. VIRGINIA
COWPASTURE R.
TO BALTIMORE MD.
TO ROANOKE VA.
JAMES R.
TO WASHINGTON D.C.
APPOMATTOX
RICHMOND
RAPPAHANNOCK R.
CHESAPEAKE BAY
JAMES R.
NORFOLK
VIRGINIA
NORTH CAROLINA
TO HOUSTON TEXAS
TO RALEIGH N.C.
HEAVY DUTY ROAD
MEDIUM DUTY ROAD
PRINCIPAL RAIL LINES
PORTS HANDLING 1 MILLION TONS PLUS
PETROLEUM PIPELINE

FIGURE K-32

Service Factors

The industrial production of coal is tremendously significant to navigation as the United States has been blessed with one of the World's largest known reserves of coal. Waterborne commerce is also aided by the industrial activity in primary metals, and the mining of stone, clay, sand and gravel.

Commodity demand is generated by 1 million people who live within a few miles of the James Estuary. The magnitude of demand is favorable to navigation. However, in the case of petroleum commerce, almost all of the tonnage to the Richmond area is by means of pipeline, not by water.

COMMERCIAL NAVIGATION

Commodity Distribution

The most outstanding aspect of Table K-86 is the preponderance of exports which is not mirrored in any other port in the North Atlantic Region. The second aspect of the exports is that they are commodities which are relatively cheap and abundant on a World-wide basis, and therefore, particularly sensitive to fluctuations in transportation costs.

TABLE K-86
COMMODITY DISTRIBUTION - AREA 21

		1955		1965		1968	
Total - 1000's of tons		56,545	100%	57,687	100%	57,843	100%
Coal	F/E	37,361	66%	38,752	67%	36,832	64%
Sand and Gravel	L	1,272	2%	3,319	6%	4,100	7%
Grains	F/E	950	2%	1,860	3%	2,150	4%
Residual Fuel Oil	F/I	3,725	6%	2,897	5%	3,695	6%
Distillate Fuel Oil	D/I	1,989	3%	1,565	3%	1,240	2%
Fertilizer	F/E	512	1%	142		1,176	2%
Clay	L			487	1%	367	1%
Jet Fuel/Kerosene	D/I	1,118	2%	531	1%	617	1%
Gasoline	D/I	4,892	9%	2,160	4%	1,861	3%

F = Foreign, D = Domestic, L = Local, I = Import, E = Export.

Major Ports

Norfolk. Norfolk is the portion of Hampton Roads lying to the south of the James Estuary. The port includes portions of the estuary and several rivers which pass through the town. U. S. Navy facilities

are adjacent to the 45-foot deep access channel from Chesapeake Bay. In the vicinity of the Elizabeth River, just to the south, are the principal coal and grain facilities of Norfolk served by the Norfolk & Western Railroad. They have adjacent depths of 36 to 47 feet and are supported by coal storage, grain storage and petroleum storage. Directly opposite, across the 45-foot deep channel, is Craney Island which has facilities for handling containerized cargo. Adjacent to and north of Craney Island, a land fill disposal area for channel spoil was completed in 1958. It is estimated that this area will be filled to capacity by 1979. Improved channels extend several miles up the branches of the Elizabeth River. A 40-foot channel extends from the entrance channel as far as the Norfolk Naval Shipyard and major oil handling facilities supported by petroleum storage (700,000 tons). A further channel extension at a 35-foot depth terminates in a turning basin, which is the northern terminus of the Atlantic Intracoastal Waterway, which extends to Florida. Other branches of the Elizabeth River serve general cargo handling facilities, shipyards, yachting clubs, recreational boating, and commercial fishing fleets with access channels with authorized depths ranging from 18 to 35 feet.

Waterborne commerce grew at an average annual rate of 2.5% over the 19-year period ending in 1967, but declined sharply to an average growth of only 0.5% during the last 10 of those years. Commerce averaged 40,400,000 tons for the three years prior to 1968. The 1970 commerce was 53,600,000 tons. As this represents an abnormally high total, it was discounted when projecting the harbor'sprospective commerce.

TABLE K-87
PORT SUMMARY - NORFOLK HARBOR

PROJECTED RANGE OF WATERBORNE COMMERCE

	1970	1980	2000	2020
Millions of Tons	53.6	50.0-55.0	71.5-81.6	105.8-134.0

DEVELOPMENT PROGRAMS

	1970	1980	2000	2020
Channel Depth (ft)	35-45	40-55 1/	40-65 1/	-
Improvement Cost($Millions)	-	90	250	-

1/ Alternative plan. Construction of a deep-draft facility in Hampton Roads or offshore at an estimated cost of $450 million. In addition, consideration should be given to the deepening to a 40-foot depth of the Southern Branch of the Elizabeth River.

Newport News. A 5-mile long channel, which is 45 feet deep and 800 feet wide, extends from the entrance channel at Hampton Roads to the deep water of the James River. Newport News facilities are located along the northern shore of the James River and include coal handling facilities, general cargo facilities, and the Newport News Shipbuilding and Drydock Co. The facilities are fully supported by the road and railroad network.

Waterborne commerce grew at an average annual rate of 1% over the 19-year period ending in 1967 but underwent a drastic average annual rate of decline of 4.2% over the last 10 of those years. Commerce averaged 17,400,000 tons for the three years prior to 1968. Commerce in 1970 was 23,600,000 tons. As this is an abnormally high figure, it has been discounted in projecting prospective commerce.

TABLE K-88
PORT SUMMARY - NEWPORT NEWS

PROJECTED RANGE OF WATERBORNE COMMERCE

	1970	1980	2000	2020
Millions of Tons	23.6	17.0-25.0	23.6-30.4	37.1-50.0

DEVELOPMENT PROGRAM

	1970	1980	2000	2020
Channel Depth (ft)	45	-	53	58
Improvement Cost ($Millions)	-	-	110	175

James River. From Newport News, an improved channel extends 90 miles through the James Estuary and River to a turning basin just south of Richmond, providing a minimum depth of 25 feet for a minimum width of 200 feet. The authorized project calls for a 35-foot deep channel, 300 feet wide to Richmond Terminal and an 18 by 200-foot channel in Richmond. Creeks and rivers are scattered along the river, most of which have been developed for fishing and recreational craft and have depths between 4 and 8 feet. Dams across the rivers and creeks often prevent further navigation even if one ignores the shallowness of the streams.

Most of the commercial facilities are found just south of Richmond and include transit sheds, warehouses, repair facilities and petroleum storage.

Waterborne commerce has undergone an almost imperceptible growth over the 19-year period ending in 1967 and in fact was static over the last 10 of those years. Commerce averaged 4,960,000 tons for the three years prior to 1968. The 1970 commerce was 7,300,000 tons, mostly sand, clay, gravel, or fuel. Approximately one-third of the commerce travels as far as Richmond. The 1970 commerce has been discounted in projecting commerce as it is abnormally high.

TABLE K-89
PORT SUMMARY - JAMES RIVER

PROJECTED RANGE OF WATERBORNE COMMERCE

	1970	1980	2000	2020
Millions of Tons	7.3	6.0-7.5	8.0-9.6	11.4-15.0

DEVELOPMENT PROGRAM

	1970	1980	2000	2020
Channel Depth (ft)	25	35	-	-
Improvement Cost($Millions)	-	60	-	-

Little River. The Little River flows into Chesapeake Bay just west of Norfolk. Its waterway is 400 feet wide and has a project depth of 20 feet. The head of the channel serves as a terminal for rail facilities of the Penn Central Railroad and has extensive marina facilities. It has been proposed to build a Virginia Beach Industrial complex bordering the waterway.

Waterborne commerce shows an average growth over the 19- and 10-year periods ending in 1967, but this masks sharp declines occasionally experienced in the middle of the periods. Commerce averaged 271,000 tons for the three years prior to 1968. The 1970 commerce was 220,000 tons, all sand and gravel and crushed rock. Commerce is expected to range between 200,000 tons and 2,000,000 tons dependent upon waterfront developments.

TABLE K-90
PORT SUMMARY - LITTLE RIVER

PROJECTED RANGE OF WATERBORNE COMMERCE

	1970	1980	2000	2020
Millions of Tons	0.2	0.2-0.5	0.2-1.0	0.2-2.0

DEVELOPMENT PROGRAM

Not estimated. Dependent upon waterfront development.

RECREATIONAL BOATING

As in the other Areas around Chesapeake Bay, the waterway conditions of Area 21 are very favorable to recreational boating. Most of the boating will take place on either the rivers or Bay because there are no significant inland lakes. Between the coastal portion of Area 21 and Richmond, there are some 90 boating facilities with about 3,000 permanent slips or moorages and 66 launching facilities. Private enterprise can be expected to satisfy most of the recreational boating needs.

TABLE K-91
SUMMARY - AREA 21

COMMERCIAL NAVIGATION

PROJECTED RANGE OF WATERBORNE COMMERCE

MAJOR PORTS

	1970	1980	2000	2020
Millions of Tons	84.7	73.2-88.0	103.3-122.6	154.5-201.0

INITIAL CAPITAL COSTS 1/

	1980	2000	2020
Millions of Dollars	150	360	175

1/ Costs shown are for channel improvements. Excludes cost of the alternative plan, for a deep draft facility in Hampton Roads, estimated at $450 million.

RECREATIONAL BOATING

PROJECTED PLEASURE CRAFT

	1970	1980	2000	2020
Registered Craft*	28,000	32,000	40,300	49,700
Total Craft	44,000	51,000	77,700	125,000

*Virginia - 10 or more hp.; West Virginia - over 5 hp.

INITIAL CAPITAL COSTS
(millions of dollars)

	1980	2000	2020
Berths	2.7	5.5	6.3
Launching Facilities	0.2	0.5	1.0

TABLE K-92
SUMMARY - SUB-REGION F

COMMERCIAL NAVIGATION

PROJECTED WATERBORNE COMMERCE

	1970	1980	2000	2020
Millions of Tons	93.3	82.8-100.2	116.0-141.7	170.7-232.0

INITIAL CAPITAL COSTS 1/

	1980	2000	2020
Millions of Dollars	174	360	175

1/ Costs shown are for channel improvements. Costs of deep-draft terminals in Areas 19 and 21 are not reflected.

RECREATIONAL BOATING

PROJECTED PLEASURE CRAFT

	1970	1980	2000	2020
Registered Craft*	51,000	61,200	88,000	119,100
Total Craft	91,900	104,200	178,300	241,200

*Maryland - over 7.5 hp.; West Virginia - over 5 hp.; Virginia - 10 or more hp.

INITIAL CAPITAL COSTS
(millions of dollars)

	1980	2000	2020
Berths	14.1	17.9	20.9
Launching Facilities	0.6	2.4	2.3

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